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HUMAN RESOURCES

LABORATORY

AIR FORCE HUMAN RESOURCES LABORATORY
MISSION AND CAPABILITIES

Edited by

Ruth M. Buescher
Michelle Olvera
Leasley Besetsny

INFORMATION SCIENCES DIVISION
Brooks Air Force Base, Texas 78235-5601

May 1989
Final Technical Paper for Period October 1986 – September 1987

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5601

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publications and presentations,
simulation and training devices,
technical achievements,
weapon systems logistics and maintenance.

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This technical paper presents the Air Force Human Resources Laboratory mission and capabilities. It outlines the AFHRL organizational structure, functions of the divisions and staff offices, and available technical support. Technical support includes software and data base development, data processing, computer operations, and scientific and technical information services. Ongoing and completed research and development (R&D) efforts are described to identify Laboratory capabilities. These R&D projects cover the areas of manpower and personnel, education and training, simulation and training devices, and logistics and human factors. (Keywords) /

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AIR FORCE HUMAN RESOURCES LABORATORY

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MISSION AND CAPABILITIES

AIR FORCE SYSTEMS COMMAND

AIR FORCE HUMAN RESOURCES LABORATORY (AFHRL)

A designated organizational element of the Air Force Systems Command, aligned under the Human Systems Division.

HAROLD G. JENSEN, Colonel, USAF
Commander

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CONTACTS: A directory of AFHRL Command and Staff personnel and Division Chiefs is provided on the inside back cover.

NOTE: The findings in this report are not to be construed as an official position of the Department of the Air Force, unless so designated by other authorized documents.

Department of the Air Force
AIR FORCE HUMAN RESOURCES LABORATORY
Brooks Air Force Base, Texas 78235-5601

AIR FORCE HUMAN RESOURCES LABORATORY

MISSION AND CAPABILITIES

Coordinated and Edited by

Dr. Ruth Buescher
Ms. Michelle Olvera
Mr. Leasley Besetsny

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AFHRL CHAIN OF COMMAND

THE DEPARTMENT OF THE AIR FORCE

The mission of the Department of the Air Force is "to provide an Air Force that is capable, in conjunction with the other Armed Forces, of preserving the peace and security of the United States, providing for its defense, supporting the national policies, implementing the national objectives, and overcoming any nation responsible for aggressive acts that imperil the peace and security of the United States." Teamed with the Army, Navy, and Marine Corps, the Air Force is prepared to fight and win any war if deterrence fails.

AIR FORCE SYSTEMS COMMAND

Major Commands are interrelated and complementary, providing offensive, defensive, and support elements. Each support function, such as logistics, training, and research and development, is under the jurisdiction of a separate command. Air Force Systems Command (AFSC) is one such command. Under policies established by HQ USAF, AFSC's mission is to advance aerospace technology, to incorporate those advances in the development and improvement of aerospace systems, and to acquire qualitatively superior, cost-effective, and logistically supported aerospace systems and equipment. It is through AFSC that USAF's operational and support commands receive the weapons, equipment, and initial spare parts needed to defend the nation.

AIR FORCE HUMAN SYSTEMS DIVISION

The Human Systems Division (HSD) is a subordinate element of AFSC. HSD plans, manages, and conducts research, engineering development, and acquisition programs and provides specialized operational support. Its efforts focus upon the readiness, maintenance, protection and enhancement of human capabilities and human system performance of individuals, teams, crews, and force levels. It serves as a center for human systems advocacy, enabling the Air Force to meet current and future operational requirements in the four functional areas of crew-system integration, crew protection, force readiness, and environmental protection.
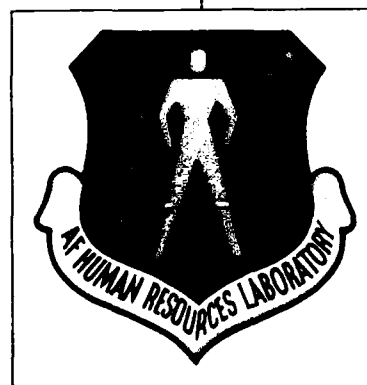
AIR FORCE HUMAN RESOURCES LABORATORY

The Air Force Human Resources Laboratory (AFHRL), an organization of HSD, has the responsibility of managing and conducting research, exploratory and advanced development programs for manpower and personnel, operational and technical training, simulation, and logistics systems. The overall goal of the combined programs is to assist the Air Force in achieving the best methods for acquiring enlisted and officer members, and training and maintaining this force at peak readiness.
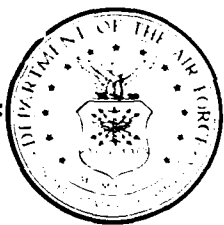
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AFSC GOALS

MEET OUR USERS NEEDS
- Keep Close
- Respond to Their Requirements
- Be Knowledgeable of Their Environment

MAINTAIN ACQUISITION EXCELLENCE
- Outstanding People
- Productive Teamwork
- Effective Strategies

ENHANCE TECHNOLOGICAL SUPERIORITY
- Nurture the Technology Base
- Transition to Operating Forces

HUMAN SYSTEMS DIVISION
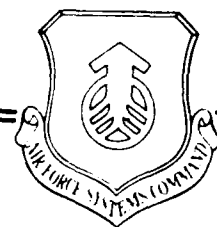
A UNIQUE FAMILY OF AIR FORCE ORGANIZATIONS, FACILITIES AND PEOPLE WITH THE SINGULAR RESOLVE OF EXCELLENCE ATTAINED THROUGH:

★ **INNOVATION**　　　　　★ **PURPOSE**

★ **LEADERSHIP**　　★ **PRIDE**

★ **INTEGRITY**

─── PEOPLE ───

★ Stimulate professional development and growth

★ Foster proper career development

★ Recognize initiative, creativity, and innovation

─── ORGANIZATION ───

★ Enhance quality of life

★ Optimize organizational interfaces

★ Maximize productivity through efficient business practices

PRODUCT

★ Human centered systems design and development

★ Enhanced crew-system integration

★ Assured crew protection

★ Increased medical and force readiness

★ Optimum environmental protection

★ Excellence in aerospace medical education and training programs

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Dedicated To Solving The Human Challenges In Air Force Systems And Operations

MESSAGE FROM THE COMMANDER

Let the word go forth from this time and place, to friend and foe alike, that the torch has been passed to a new generation of Americans, born in this century, tempered by war, disciplined by a hard and bitter peace, proud of our ancient heritage, and unwilling to witness or permit the slow undoing of those human rights to which this nation has always been committed, and to which we are committed today at home and around the world.
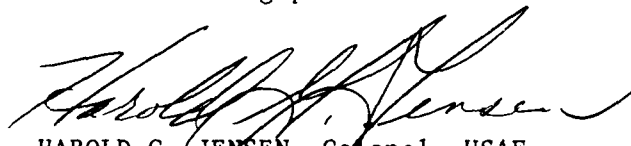
Let every nation know, whether it wishes us well or ill, that we shall pay any price, bear any burden, meet any hardship, support any friend, and oppose any foe to assure the survival and success of liberty.

John F. Kennedy (1917-1963)
Inaugural Address (20 January 1961)

These words come to mind as I sit back and reflect on the purpose of our organization, the Air Force Human Resources Laboratory (AFHRL). And I ask myself, "What is the singular function of AFHRL? Is it to help select and train the best pilots? Is it to support increasingly sophisticated weapon systems and technology? Is it to carry out research aimed at making a more efficient and effective work force? Is it to design the best training program on the job and in combat?" The purpose of AFHRL is all of these things, yet more. For in the most global and purest sense, our purpose is to work toward the preservation of freedom and human dignity.

With all the achievements of AFHRL, it serves me well to step back and simply look at the bigger picture, and try to put into words what it is that we are actually working toward. As I examine our purpose, our challenges, and our accomplishments, I look toward our horizons--where we have been, and where we are going. And, as I view AFHRL, I think the words of John F. Kennedy capture the essence of our mission and, in fact, our being. They eloquently state our purpose as an Air Force organization that serves an important role in our Nation's quest for an enduring peace.

HAROLD G. JENSEN, Colonel, USAF
Commander

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AFHRL Headquarters Building

HUMAN RESOURCES LABORATORY MAKES VALUABLE CONTRIBUTIONS TO THE AIR FORCE

The Air Force Human Resources Laboratory (AFHRL), headquartered at Brooks AFB, Texas and commanded by Col. Harold G. Jensen, is the principal Air Force Systems Command (AFSC) organization charged with planning and executing the Air Force exploratory and advanced development programs for research and development (R&D) related to manpower and force management, logistics systems technology, and training technology.

The AFHRL mission is related to all functional areas of the Air Force since there is no area that escapes the requirement for trained and qualified personnel. The Laboratory executes its mission through R&D programs in training, personnel, and logistics systems technology. These include programs in force selection, classification, and utilization; programs in education and technical training, flying training, and team training; programs

to develop simulators for flight and maintenance training; and logistics and human factors programs in weapon systems acquisition and combat maintenance.

AFHRL is comprised of five divisions whose overall goal is to assist the Air Force in achieving the best methods of acquiring and utilizing enlisted and officer members, and training and maintaining this force at peak readiness.

There are four research divisions within AFHRL, located in various parts of the United States. The Manpower and Personnel Division, Brooks AFB, develops methods for identifying individuals who can best contribute to the Air Force mission and techniques to assign them to jobs that match as nearly as possible their talents and preferences. The Training Systems Division, also at Brooks, develops improved individual and unit training

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methods and strategies for skills development, leading to effective job performance. Located at Wright-Patterson AFB, Ohio, the Logistics and Human Factors Division focuses on computer science, human factors, operations research, and engineering skills in an interdisciplinary systems approach to R&D of new logistics and command/control capabilities. The Operations Training Division, Williams AFB, Arizona, is the only Air Force agency devoted to the exploitation of science and technology to improve aircrew training.

AIR FORCE HUMAN RESOURCES LABORATORY
BROOKS AFB, TX

HSD

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                        |    COMMANDER     |
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                        |    COMMANDER     |
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|   TECHNICAL      |      |   SPECIAL        |      |   EXECUTIVE      |
|   PROGRAMS &     |      |   PROJECTS       |      |   SUPPORT        |
|   RESOURCES      |      |   OFFICE         |      |   OFFICE         |
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| TRAINING   |  | OPERATIONS |  | LOGISTICS &|  | MANPOWER & |  | INFORMATION |
| SYSTEMS    |  | TRAINING   |  | HUMAN      |  | PERSONNEL  |  | SCIENCES    |
| DIVISION   |  | DIVISION   |  | FACTORS    |  | DIVISION   |  | DIVISION    |
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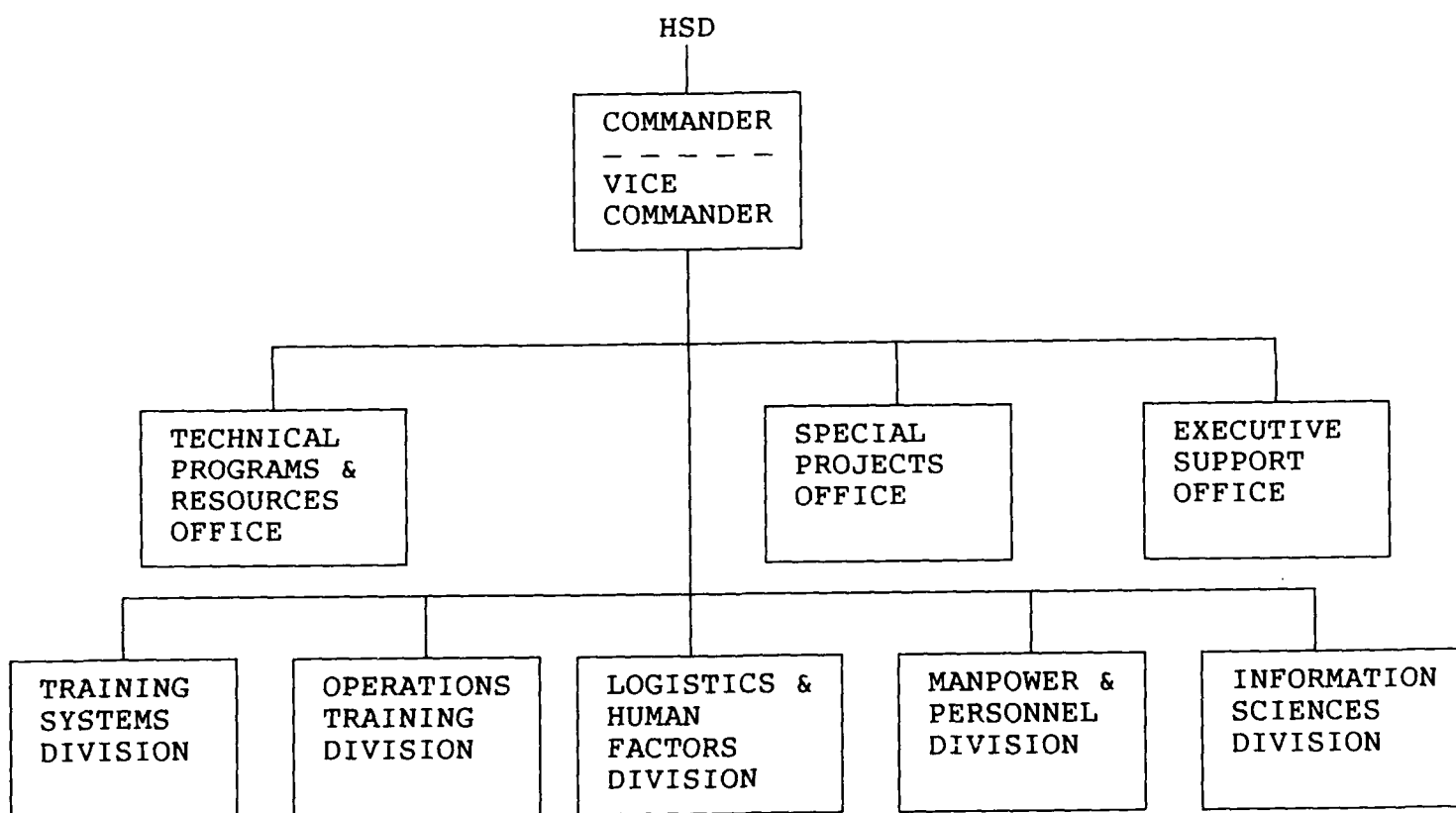
TECHNICAL PROGRAMS AND RESOURCES OFFICE

The Technical Programs and Resources Office is responsible for the development and implementation of procedures and policies for the initiation and execution of Research, Development, Test, and Evaluation (RDT&E) programs for AFHRL. It provides overall resource management for the Laboratory, which includes all Laboratory funding and funding from outside sources. The resource function develops and maintains resource allocation models and is responsible for planning, organizing, and executing special studies to develop recommendations for the distribution of resources to ongoing and projected RDT&E programs. The Office provides guidance to the AFHRL staff and division management with respect to funding levels on specific RDT&E programs and provides general guidance and oversight to the transfer and transition of AFHRL technologies. The Office also evaluates Independent Research and Development projects of industry and tracks Laboratory accomplishments.

SPECIAL PROJECTS OFFICE

The Special Projects Office conducts studies, analyses, and evaluations of current and planned AFHRL programs with respect to the effective use of AFHRL resources and conformance with Air Force, AFSC, HSD, and AFHRL policies.
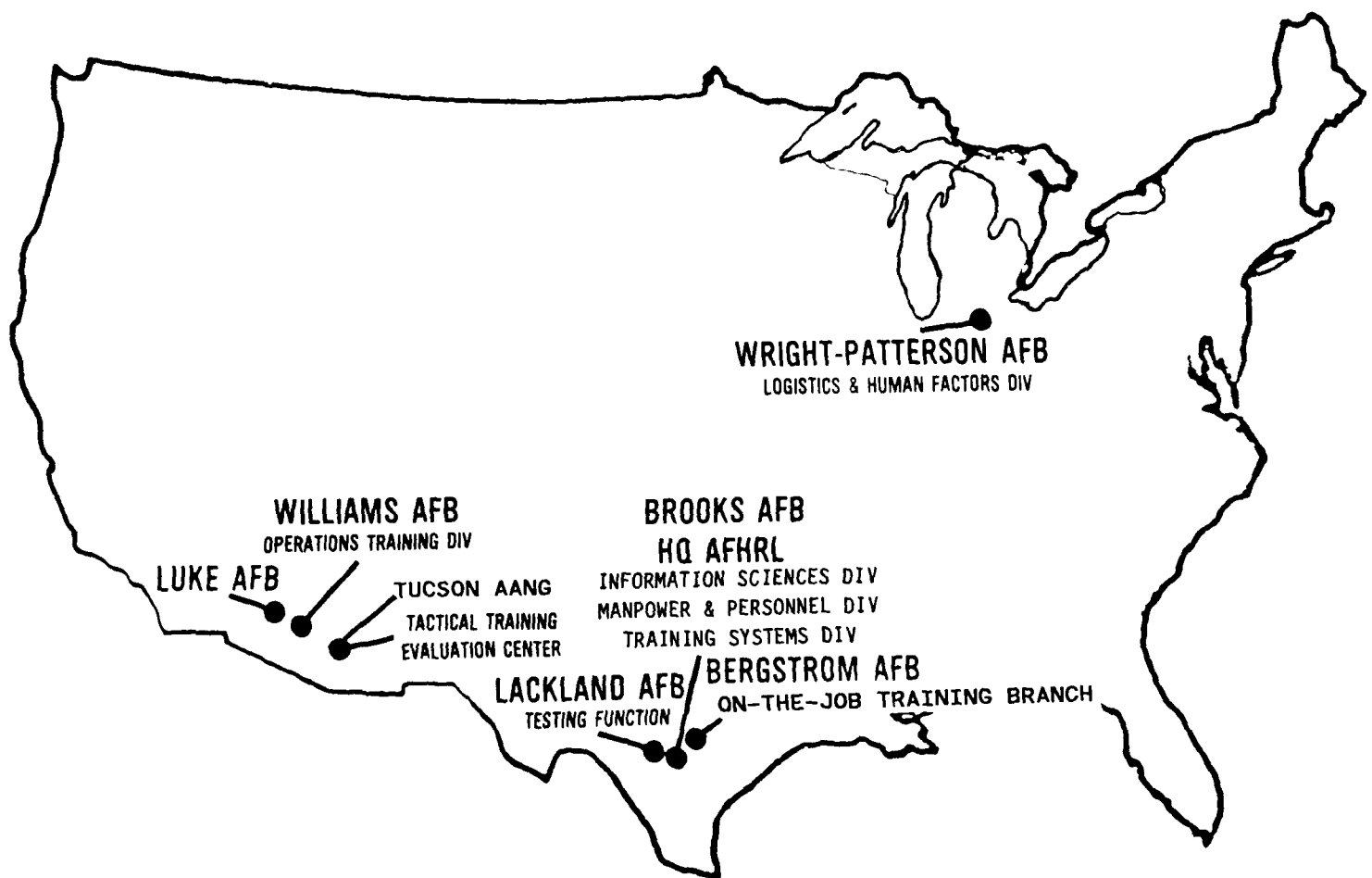
The studies relate to any aspect of R&D or business management within AFHRL. The office also develops and evaluates plans in new areas, coordinates plans with other organizations, conducts and monitors front-end analyses, and maintains liaison with other laboratories and user organizations.

EXECUTIVE SUPPORT OFFICE

The Executive Support Office develops and implements policies, procedures, and standards relating to administration management and practices, military and civilian personnel and manpower actions, and materiel actions. The Office provides staff guidance, assistance, and surveillance over other echelons in areas of functional responsibility for the Laboratory Commander.

The Office staff operates the following programs: manpower and organization, reports management, documents security, military and civilian personnel administration (including training programs), and organizational supply. Further, the Executive Support Office is the principal focal point for host-tenant support agreements for the Laboratory, represents the Laboratory in dealings with other agencies and higher headquarters in all areas of functional responsibilities, and serves as focal point for Inspector General visits and reports.

AFHRL GEOGRAPHIC LOCATIONS

WRIGHT-PATTERSON AFB
LOGISTICS & HUMAN FACTORS DIV

WILLIAMS AFB
OPERATIONS TRAINING DIV

LUKE AFB

TUCSON AANG
TACTICAL TRAINING
EVALUATION CENTER

BROOKS AFB
HQ AFHRL
INFORMATION SCIENCES DIV
MANPOWER & PERSONNEL DIV
TRAINING SYSTEMS DIV

BERGSTROM AFB
ON-THE-JOB TRAINING BRANCH

LACKLAND AFB
TESTING FUNCTION

The Logistics and Human Factors Division (LR) conducts research and development (R&D) on maintenance and logistics systems, team training (except flying training), and team performance in ground-based systems. Logistics R&D includes developing maintenance aids and diagnostic processes, techniques for considering logistics throughout system design and acquisition, methods for forecasting logistics resource requirements, and techniques for assessing combat maintenance readiness and capability of integrated logistics systems. LR is responsible for team performance and training which include development of content, sequence and media with emphasis on techniques for training of command and control (C^2) teams, as well as ground-based teams for space operations.

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                ┌─────────────────┐
                │  LOGISTICS &    │
                │  HUMAN FACTORS  │
                │  DIVISION       │
                └─────────────────┘
┌───────────────┐         │         ┌───────────────┐
│  TECHNICAL    │         │         │  PROGRAM      │
│  DIRECTOR     │─────────┼─────────│  SUPPORT      │
│               │         │         │  OFFICE       │
└───────────────┘         │         └───────────────┘
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ACQUISITION LOGISTICS BRANCH	LOGISTICS SYSTEMS BRANCH	GROUND OPERATIONS BRANCH	COMBAT LOGISTICS BRANCH
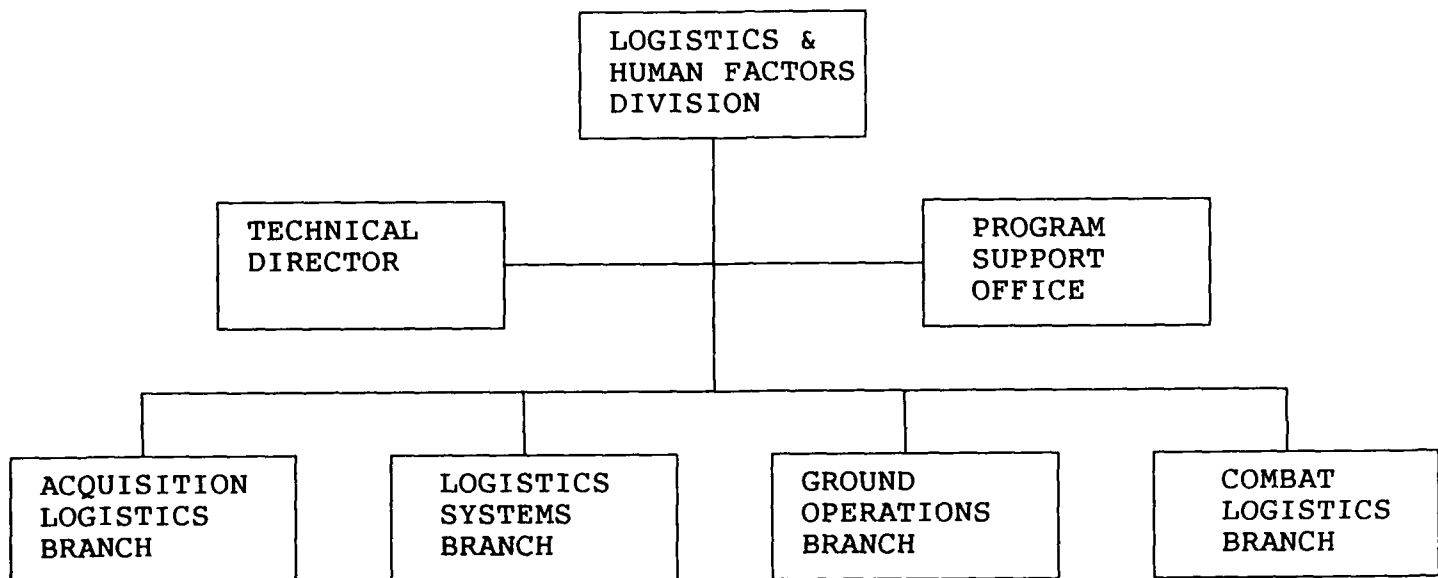
ACQUISITION LOGISTICS BRANCH (LRA)

The objective of this Branch is to provide the technological components of structured engineering information systems and automated management processes for acquiring more supportable and sustainable systems. Key program areas address the exploitation of computer technology for designed-in supportability and the integration of automated technical information.

A modern aerospace vehicle is a complex integration of sophisticated technical systems manufactured to the exacting standards required to achieve mission performance, cost, safety, and schedule requirements. The complexity of the design, manufacturing, and support process has increased significantly as a result of the high technology employed. Traditional methods for performing these

A modern aerospace vehicle is a complex integration of sophisticated technical systems.

functions are, however, manpower intensive and costly, and generate enormous volumes of information (paper) which must be managed manually. The application of computer technology has provided the designer, the manufacturer, the manager, and the maintainer with the capability to dramatically increase their productivity. Yet these capabilities have only partially exploited the potential for design, manufacture, support, and automated data communication between these processes.

Reliability, Availability, and Maintainability in Computer-Aided Design (RAMCAD)

AFHRL/LRA is conducting R&D that will increase productivity throughout the weapon system life cycle by effectively utilizing computer technology during the acquisition process. The Unified Life Cycle Engineering (ULCE) projects will provide the design engineer with the techniques to develop reliable, supportable, and producible designs. The Integrated Design Support (IDS) System will provide the weapon system manufacturers and supporters access to the information generated during the acquisition process.

This effort will develop analytical models, computer software, data bases, and work procedures for including maintenance and logistics factors in the CAD of systems and equipment. Computer-aided engineering techniques have helped reduce the design burden, making it possible to now incorporate logistics and Reliability and Maintainability (R&M) considerations during the initial design phases.

A wide spectrum of CAD technologies for industrial design are being developed in the commercial marketplace. These CAD technologies substantially enhance drafting capabilities and the hardware design process. Since maintenance and logistics considerations are not formally a part of the drafting process, there is little industrial motivation to develop and incorporate these aspects into CAD.

The main purpose of this technology is to improve designed-in supportability of weapon systems. This will be accomplished in three ways: (a) more reliable avionics through the automation of the Avionics Integrity Program (AVIP) process; (b) increasing the information science technology base throughout industry and
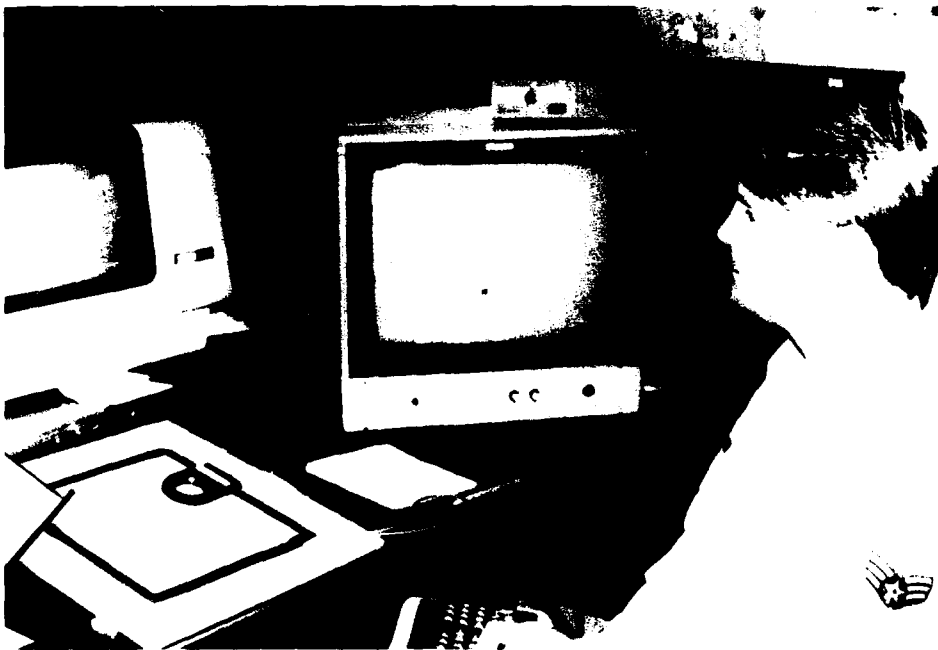

Effectively using computer technology during
the acquisition process will increase productivity.

Government relating to supportability and producibility analyses (ULCE); and (c) aiding the general automation of industrial and governmental processes in the acquisition and logistics areas (CALS). CAD technologies substantially enhance drafting capabilities and the hardware design process. One major aerospace company has estimated a 15:1 payoff for their current CALS investments if applied to a five-year major weapon system development effort. Improved R&M will significantly lower system life-cycle costs and result in higher states of combat readiness. Other direct benefits include: a more efficient design process; more explicit trade-offs in the design; and better R&M analysis techniques, which can be implemented throughout the design phase of weapon system acquisition. This program has been divided into two major parts:

(1) A series of high-visibility, quick payoff (less than two years) demonstration projects to provide hard evidence of the benefits achievable by the incorporation of reliability, maintainability, and logistics into CAD. Demonstrations were conducted using the Ground Launched Cruise Missile and the F-15E as platforms. A pair of demonstrations on the Integrated Electronic Warfare System (INEWS) will be completed in 1988.

(2) A longer-term development goal is to provide a minimum standard of CAD-based supportability analysis across the aerospace industry. Included is the development of analytical models, computer software, data bases, users manuals, and specifications for a fully integrated reliability, maintainability, and performance engineering CAD capability.

RAMCAD also includes development of techniques through a university-industry consortium and demonstration of ongoing weapon system development programs. To ensure continuity of effort, close coordination is being maintained with the National Security Industrial Association working group on RAMCAD and the Joint Logistics Commanders' working group for RAMCAD. The final demonstration and test of RAMCAD is scheduled in FY90.
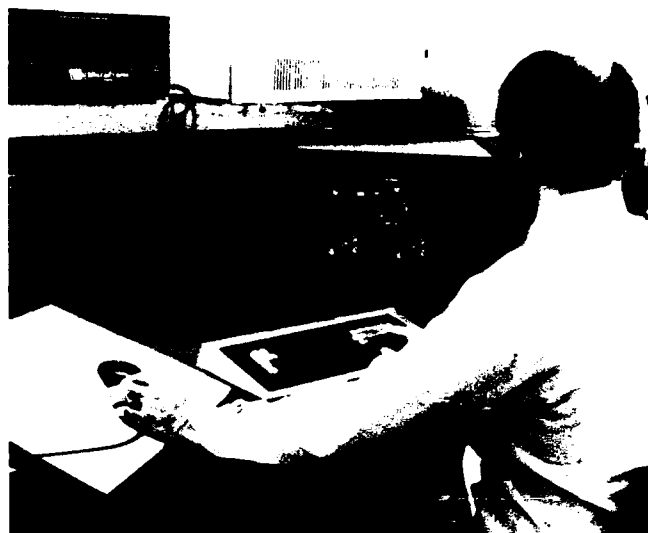
RAMCAD will enable engineers to develop reliable, supportable, and producible designs.

According to a 1985 AGARD advisory report, 10 percent of American design is being accomplished using computer-aided engineering (CAE) and this portion is growing at a 30 to 50 percent annual rate. It is estimated that by 1995 this figure will be nearly 80 percent.

On 24 September 1985, Deputy Secretary of Defense William H. Taft IV signed a memorandum approving the Office of the Secretary of Defense (OSD) Computer Aided Acquisition and Logistics Support (CALS) initiative. This effort requires DOD to automate its logistics functions by 1990 and has three objectives:

(1) Accelerate the integration of R&M design tools into contractors' computer-aided design and engineering processes.

(2) Accelerate the automation of contractor processes for logistics technical information.

(3) Rapidly increase DOD capabilities to receive, distribute, and use logistics technical information in a digital form.

These objectives were reinforced in the recently completed Air Force Systems Command Project Forecast II Study, in which the use of CAE to address the design of weapon systems for performance, as well as for manufacturing and support, was identified as a crucial technology. This Forecast II initiative was called Unified Life Cycle Engineering (ULCE). RAMCAD forms a critical part of both the OSD CALS and the AFSC ULCE activities.

The second portion of this effort will be accomplished through a tri-Service cooperative effort of Government, industry, and academia. This activity will be managed by the Air Force Human Resources Laboratory with the advice and consent of a board of advisors from the Army, Navy, the Defense Advanced Research Projects Agency, the Air Force Office of Scientific Research, and other Air Force laboratories. In this way, limited resources can be leveraged for maximum benefit to the entire DOD community while shortening the required development time.

This part consists of three tasks. Task 1 is to integrate several diverse commercially available software programs with a standard CAE system. Task 2 is to conduct longer-range R&D on technologies critical to the success of RAMCAD. Task 3 is directed at developing an engineering curriculum incorporating RAMCAD for use in undergraduate and continuing education programs. This will help to institutionalize RAMCAD in the engineering community. These efforts will run from FY87 to FY91.

Contracts have been awarded for RAMCAD software development to TRW, General Dynamics--Convair Division, and Boeing Computer Services, supporting work under ULCE to develop a Decision Support System (DSS). This system will assist engineers in making trade-offs among numerous decision parameters.

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          Wright-Patterson AFB OH 45433
          Commercial: (513) 255-3871
          AUTOVON: 785-3871
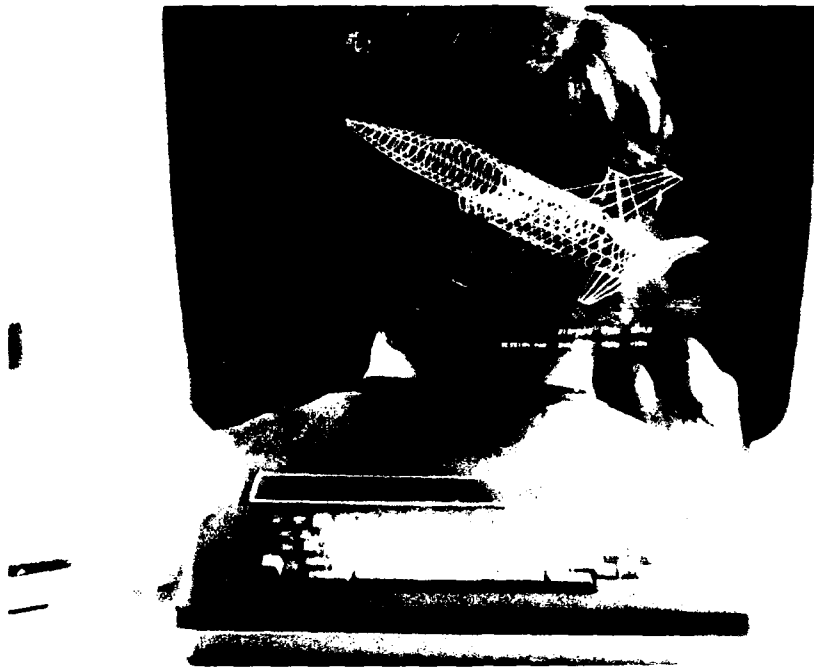
Computer-aided design will assist engineers
in making trade-off decisions.

Design Analysis Models (CREW CHIEF).

Closely related to the RAMCAD and ULCE programs is the CREW CHIEF project. Jointly with the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL), LRA is developing a computer-aided design (CAD) model of an aircraft maintenance technician. This model will interface with existing commercial CAD systems used by aerospace manufacturers and can be employed by them to improve the maintainability and supportability of Air Force aircraft. By providing the designer with a computer simulation of a maintenance technician, maintainability analyses can be performed while the system is still on the computer-aided drawing board. Specifically, CREW CHIEF represents the correct body size and proportions of a maintenance technician, the encumbrance of clothing and personal protective equipment, mobility limitations for simulating working postures, physical access for reaching into confined areas, visual access and strength capabilities.

This R&D will develop a computer graphics model and supporting data bases of Air Force technicians (male and female) for use in computer-aided methods of evaluating designs of weapon systems and equipment. The model will be used to perform mockup-type evaluations of new weapon systems and equipment designs. Humanlike characteristics such as standing, sitting, squatting, crawling, lifting, pulling, and tool usage will be featured in the model. This effort will encompass both male and female technicians and maintenance work in both standard work clothing and protective equipment. The model will be capable of evaluating a proposed design in maintainability terms such as accessibility of equipment, tool usage within access areas, maintenance operations and task requirements, and lifting load requirements. It can be used by designers to do on-line analysis during early stages of the design cycle.

It holds the promise of reducing development costs, acquisition time, and life cycle costs. The largest single effort in the development of the CREW CHIEF model is the R&D to gather supplementary ergonomics data. Data are being gathered regarding manual materials handling for the appropriate maintenance technician working postures, torque strength capability for wrenches, and electrical connectors and visual accessibility. The data base will be expanded in the future to include fatigue factors. Future work is planned to address the zero-gravity environment.

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           Wright-Patterson AFB OH 45433
           Commercial: (513) 255-3871
           AUTOVON: 785-3871

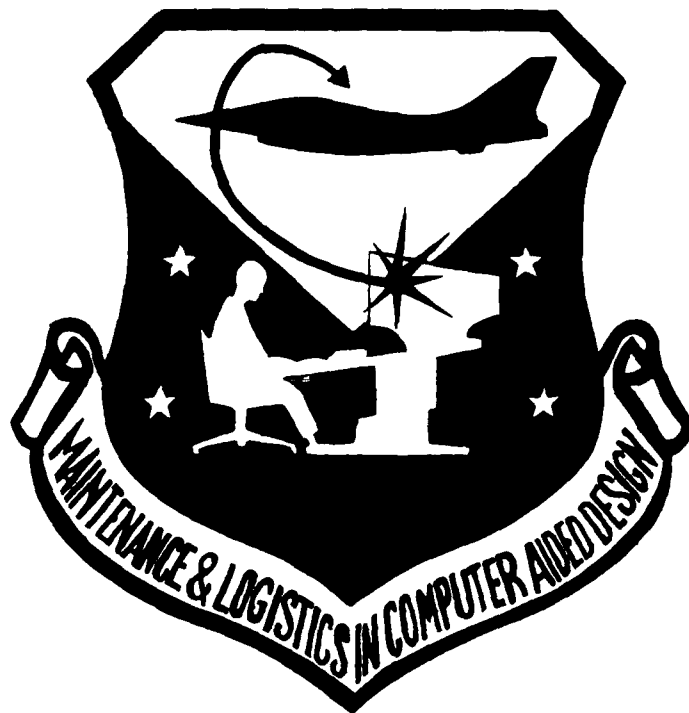Aircraft maintenance will be enhanced by development of CREW CHIEF model.

Unified Data Base

An additional effort within LRA is the Unified Data Base (UDB). The UDB is a Logistics Support Analysis data base system designed to improve the documentation accessibility of acquisition support data. This system has the capability of creating an acquisition logistics data base which can be used by Government and contractor personnel to eliminate the need for the paper-intensive logistics documentation systems. The UDB is an on-line, fully automated system capable of producing a logistics support analysis record (LSAR) which conforms to MIL-STD1388-2A. It will provide logisticians with a flexible, efficient data base application system designed to ease the burden of documenting iterative LSA tasks. The UDB will permit rapid documentation of acquisition logistics data and will also permit the data to be used as common source data for standard contract deliverable data items. It will facilitate timely analysis feedback to both weapon system designers and Government program offices. For example, through feedback logistics, requirements such as unique support equipment and interim contract support can be held to minimum levels.

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Integrated Design Support (IDS) System

Current methods used to store, find, and/or modify paper-based technical information over the life cycle of weapon systems are grossly inadequate and very expensive. Further, the proliferation of Computer-Aided Design (CAD) systems has produced CAD systems which cannot effectively communicate with each other. DOD does not currently obtain or retain adequate technical information for the complete logistics support (remanufacturing, third-party parts suppliers, replacements for obsolete parts, etc.) of most weapon systems, making DOD dependent on primary contractor support for the life of the weapon systems. In addition, problems associated with the management of technical information are widespread and well known: Engineering drawings are incomplete, illegible, and difficult to control; paper-based logistics support data are voluminous and often redundant; technical manuals rapidly become obsolete and are difficult to update; data reside in a heterogeneous computer environment and generally cannot be communicated between dissimilar computer systems. These kinds of problems result in inflated costs and reduced operational capability.

To address these problems, DOD has mandated that all new major weapon systems must acquire technical information in digital form by the 1990s. Consequently, new software and communication architectures are required to provide for engineering design, technical data communication, coordination and preservation for further DOD use (e.g., logistics, maintenance, remanufacturing, technical orders, etc). The Integrated Design Support (IDS) program is an information systems R&D effort intended to provide direct support to logistics personnel for modi-

fication, maintenance, and repair of Air Force weapon systems. IDS is attempting to solve the problems of organizing, managing, and distributing weapon system technical data across the entire life cycle of a weapon system. Advanced computer technology is being applied to integrate engineering data into what will appear to the user to be a "single" data base.

The IDS program will develop a digital software architecture that will advance existing design considerations, design specifications, manufacturing methods and parts fabrication information. It will demonstrate advanced software and communication architectures for the coordination, preservation and retrieval of weapon system engineering design technical data for DOD use (logistics maintenance, remanufacturing, technical orders, etc.). IDS is essential for future computer-based technical information systems and automated engineering data. Transition will be through specifications applied on new systems programs and by the Air Force Logistics Command under the overall Air Force program in Computer Aided Acquisition Logistics Support (CALS).

Initially, IDS will define the critical subset of weapon system technical information necessary for logistics support. Next, IDS will provide the architecture required to integrate the collection of computer systems and software which are currently used for the management of this information. Then, IDS will produce a consistent set of program requirements. Next, it will develop, demonstrate, and validate a prototype software system to meet these requirements. This will provide the foundation for full-scale development of a production IDS system. Finally, the program will produce a tangible cost benefit analysis to justify the construc-

tion and implementation of a production IDS system. IDS will integrate these data using a mix of different computer hardware and software on geographically separated systems.

IDS is creating four major products: an architecture representing the requirements and specifications for the Integrated Design Support System; an advanced prototype system demonstrating proof of concept and serving as a laboratory tool; technology transfer mechanisms to help the movement to industry; and a source of technology requirements for future weapon system information management systems. The IDS program is a joint effort with the AFWAL Flight Dynamics Laboratory. Rockwell Corporation is the prime contractor.

The Phase I contract will be completed in FY88, and Phase II will continue to FY92. An industry technical advisory group meets regularly to review and critique progress and to facilitate the technology transition.

This effort is essential for future computer-based technical information systems and automated engineering data. New software and communication architectures are required to provide for engineering design, technical data communication, and data coordination for other DOD uses. Most of these technical data are available, but there is presently no way to cost-effectively obtain and retain such data. IDS will be critical in providing an Air Force capability in this regard. A prototype IDS system demonstration in a production environment will be completed in FY91.

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LOGISTICS SYSTEMS BRANCH (LRL)

The objectives of this Branch are to extend Air Force combat planning, operations, and support capabilities through advanced logistics systems analysis, model development, and decision support technologies.

Specifically, R&D is directed toward incorporating advanced technologies and methodologies to meet war-fighting capabilities by providing the tools needed to: (a) compare and evaluate deployment/employment and support concepts of operations and predict wartime resource requirements; and (b) enhance the capabilities of decision makers within the support structure.

The R&D program is an amalgam of exploratory research and advanced development efforts with three thrusts. The first is basic analytical research. The second is model development and enhancement. These will provide the capabilities to evaluate logistics supportability in situations requiring responses to anticipated, but difficult-to-quantify events. The third is decision support technologies. This R&D program involves internal efforts, as well as cooperative work with other branches, divisions, laboratories, major commands, and the academic community.

The objective of the first thrust is to develop basic analytical research tools which more precisely reflect logistics impacts throughout the acquisition cycle. By determining relationships through the analysis of historical combat operations and support, we can extrapolate results to current and future weapon systems. Our approach is to analyze historical combat data, validate results through comparisons with actual results, and then apply these techniques to determining future requirements.

The objective of the second thrust is the development, enhancement, and application of models, simulation methods, and system capability assessment tools. These will focus on logistics demand-rate forecasting, operational capabilities, and high-fidelity requirements assessment.

The objective of the third thrust is to incorporate advanced decision support tools for use by system designers, analysts, managers, and users. Our effort on the Unified Life Cycle Engineering (ULCE) Decision Support System supports this objective. The intent is to conduct the R&D that will ensure overall system interoperability and compatibility.

Future efforts will evaluate and address the critical interfaces among development, logistics, and operations systems. These will culminate in tools essential to increase readiness through comparisons of alternative concepts and through provisions for decision support systems.
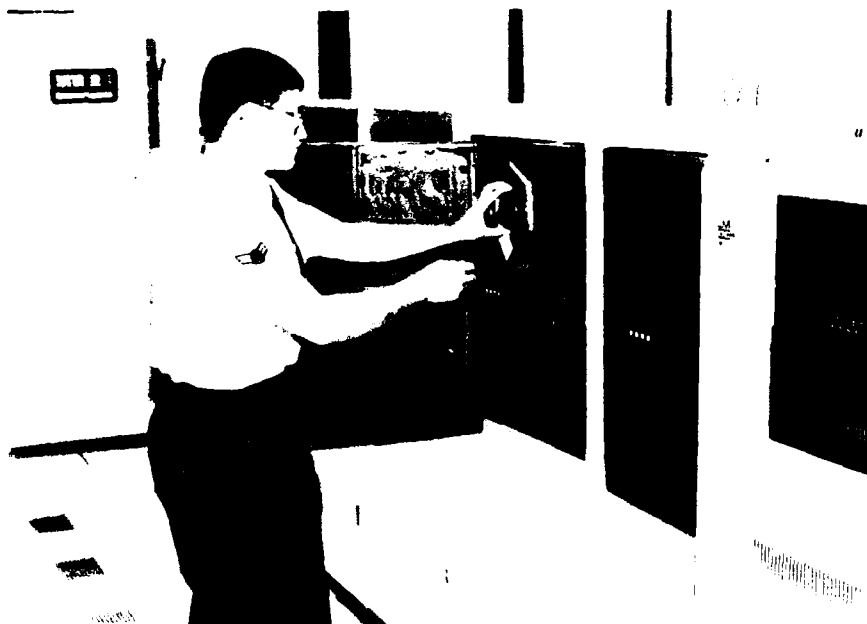
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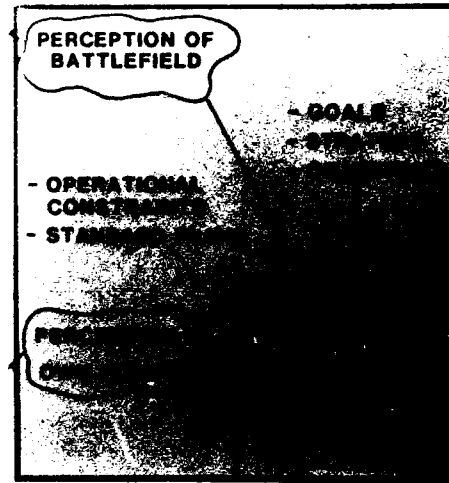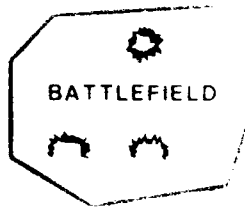
GROUND OPERATIONS BRANCH (LRG)

The mission of this Branch is to improve the combat readiness of battle managers and their staff assigned to command and control (C^2) functions through application of advanced training and human performance technology. Work accomplished has supported many Air Force activities (e.g., United States Air Forces in Europe (USAFE), Tactical Air Command (TAC), Rome Air Development Center (RADC), 9th Air Force, Electronic Systems Division (ESD), and others). LRG is engaged in R&D to improve the combat readiness of battle managers and battle staff.

The Branch is also involved in programs with other laboratories and DOD agencies. It participates with the Electronic Systems Division (ESD) in the Strategic Defense Initiative (SDI), and in the Battle Management/Command, Control, and Communications (BM/C^3) program continued

through membership in their BM/C^3 Fusion Working Group. The goal of this group is to keep the disparate BM/C^3 efforts coordinated and mutually supportive. Significant involvement was established in the Naval Research Laboratory (NRL) SDI mid-course BM/C^3 program through the provision of human factors and C^3 knowledge to NRL's Human Interface Working Group. Additionally, we joined the membership of the Battle Management Working Group for the Atmospheric Defense Initiative (ADI), the air defense companion to SDI. Support was given to the USAF School of Aerospace Medicine (USAFSAM) Generic C^2 Workstation Project, a lead-in effort for their Aircrew Evaluation Sustained Operations Performance (AESOP) Facility. The support included assistance with scenario scoping/development, hardware and software requirements determination/scoping, and facility development planning.

An important Branch program is to develop new technologies for analysis of C^2 tasks. Traditional task analysis techniques are not well suited for describing activities performed by a battle staff in a tactical C^2 system. Traditional methods rely on collecting data on observable tasks while most tactical C^2 systems involve non-observable decision making. To meet the needs, computer techniques based on structural interviewing of battle staff personnel are being developed. A prototype system is reaching completion and will be validated at the Air Support Operations Center, Bergstrom AFB, TX in FY88. A field testing program will follow.

A new program was initiated in FY87 to investigate aspects of cognitive psychology that may influence how high-performance skills may be trained. Previous work has shown that certain components of tasks can be decomposed into those that are effortless and those that require much effort to learn and perform. Work is underway to develop analytic techniques to identify those task components which can be trained relatively rapidly. This work will provide the opportunity to develop and test part-task trainers for high-performance C^2 skills.

Air Force Space Command (AFSPACECOM) and AFHRL are collaborating on the matching of AFSPACECOM R&D requirements with AFHRL R&D capabilities. As an initial step, a small-scale survey was conducted with operational personnel with relevant experience. Interviews were conducted for the purpose of identifying high-performance-demand situations or known performance limitations.

Plans are well underway to enhance the in-house C^2 training R&D facility. This facility will be used to conduct training R&D experiments based on C^2 scenarios. The R&D will focus on training for battle management staffs. Scientists here will also address the analysis of decision making. This is aimed at defining and understanding the knowledge structures which underlie performance. Until more information is obtained about these phenomena, little can be done to improve battle management training. The facility itself will consist of workstations which are capable of emulating a variety of functions within C^2 systems (e.g., Tactical Air Control System (TACS) space operations). The facility will also support other relevant Branch and Division R&D projects.

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Methods to Evaluate Automation in Tactical Command and Control (C^2) Systems

Tools do not exist to adequately predict the effects of increases in the numbers and complexity of automated systems in tactical C^2 systems; the manner in which the automation affects operator and system performance is determined only after its incorporation. This could become a very real problem for the Air Force when the current 407L control equipment of the Control and Reporting Centers (CRCs) and other radar-based elements of the Tactical Air Control System are replaced by the Modular
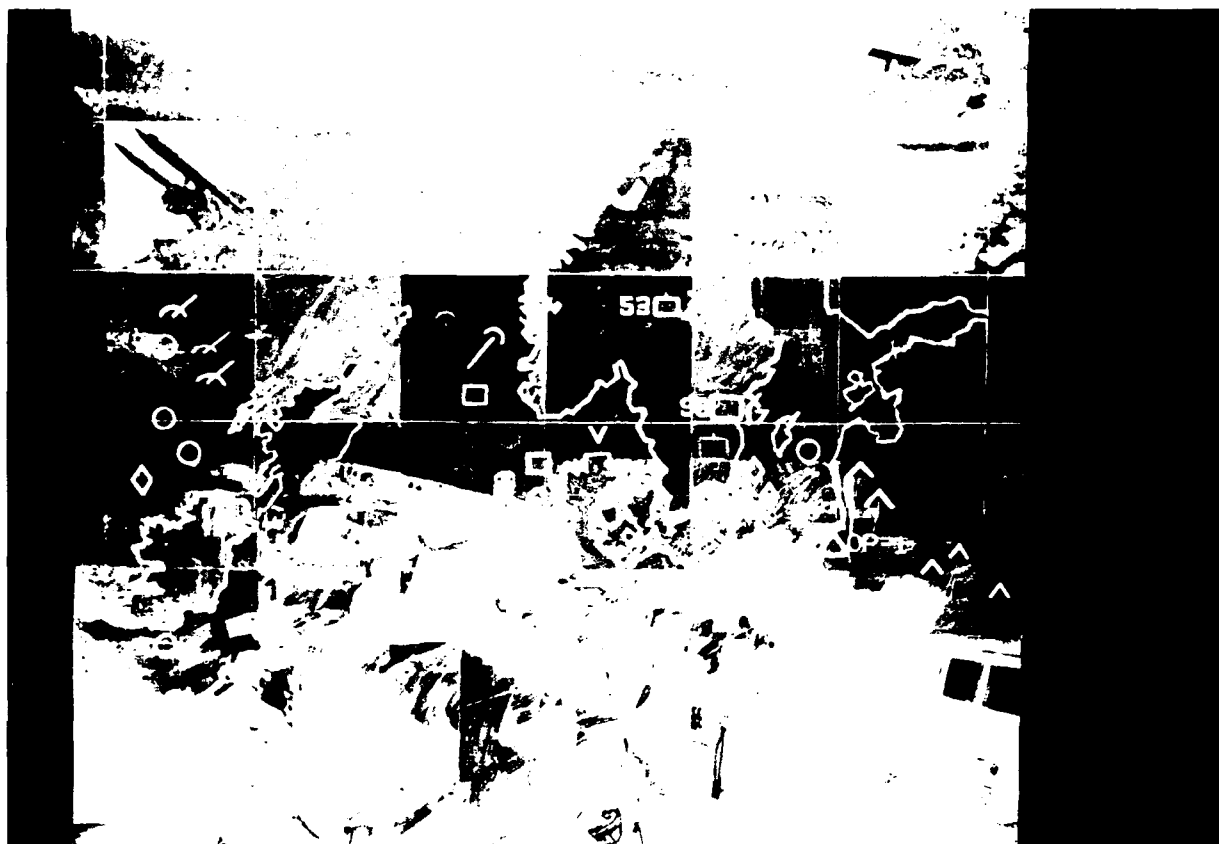
Control Equipment (AN/TYQ-23). Better-prepared and fully responsive air defense elements will be achieved through the development of a way to predict changes in operation, training, and manning requirements, by automating a Control and Reporting Center (CRC) with Modular Control Equipment (MCE), as well as the ability to make such predictions for future systems.

Through a contract with BBN Labs, Inc., this proof-of-concept effort will determine if a tactical control center can be well represented using a structured hierarchy of activity scripts (containing standardized task sequences). The representation will be tested by a computerized model using advanced object-oriented programming techniques derived from artificial intelligence (AI) R&D. Usage of AI techniques will enable simultaneous inclusion of several human performance theoretical models with an application blend appropriate for the invoked activity script.

Data collection on the CRC processes, human performance (knowledges/rules/behaviors), and MCE system is approximately 80 percent complete. Coding of the man/machine topology and underlying models has been initiated.

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Command and Control (C^2) Training Systems

The evolution of the C^2 function in the Air Force is increasing both the challenge of training C^2 teams and the payoff of such training. Future C^2 systems will involve a network of interdependent nodes; if one node is destroyed during combat, other nodes will have to assume their functions. So, C^2 teams will have to be trained to perform a

wider range of functions. In addition, the complexity of battle management will increase. With this increase come additional requirements to provide both realistic combat training opportunities and system design guidance to ensure that man-machine interaction requirements/design supports these increased operational demands. Consequently, training, human performance, wargaming, system design, and battle management decision making have emerged as major R&D interests.

AFHRL is responding to both the increased challenge and the increased potential payoffs by enlarging and upgrading its existing facility to focus on realistic C^2 training and human factors R&D. The facility will be electronically linked to both the Harry G. Armstrong Aerospace Medical Research Laboratory and the Rome Air Development Center--two other Air Force organizations with C^2 R&D responsibilities. Linkages to other DOD C^2 R&D facilities for support of the strategic defense initiative (SDI) are also planned. The upgraded facility will be used to identify better ways to train C^2 teams to function in all domains--tactical, strategic, and space operations.

The C^2 R&D program will continue to provide three kinds of products:

(1)   Training to Improve Team Performance.   This effort will develop technology to improve combat readiness training of individuals and teams assigned to the operational and logistics elements of the theater and force management levels--Tactical Air Forces (TAF). Part of the R&D will be to investigate the best ways of training personnel on the most effective methods to use when preparing air tasking orders (ATOs) and on training methods for high-level battle management decision making. In order to collect accurate and detailed information on wartime jobs (functions and tasks), an in-house effort to design and develop a computerized task data collection/analysis system is underway. When combined with a contracted effort, this new capability will allow collection of both procedural and decision-making data at the job site for C^2 positions in strategic, tactical, and space systems. This will provide the Air Force with an accurate, timely, and comprehensive data base for use in requirements analysis, training, assignments, system design, and operation. To improve the quality and reduce the cost of training and exercising C^2 battle staffs, work aimed at developing both a better understanding of complex decision making and exercising/war-gaming is underway. The

work will include investigations of human performance/decision making in physically dispersed, functionally distributed operational sites, with emphasis on the assessment of human memory capacity and automaticity. When completed, this work will lead to demonstration training prototypes, system design guidance, and exercise/war-gaming recommendations for the operational forces. New analysis technology to accurately identify, collect, and manage the actual wartime training requirements for selected positions in the Tactical Air Control Centers (TACCs) will be developed. Work will also be conducted to develop knowledge-engineering-based tools to provide customized, adaptive training programs for functional-level training in tactical C^2 operations. The potential value of photographic-based visual imagery will be explored through a series of in-house studies to determine its value in training C^2 personnel. Photogrammetric techniques combine photographic images with mapping data to provide representations of actual terrain. The use of microcomputers to provide in-garrison training programs will be investigated. Demonstration prototype microcomputer-based exercise and training programs will be developed and field tested for both individual and team training.

(2) C^2 Performance Assessment. This R&D identifies variables that impact decision-making performance, and develops and validates criterion measures for these variables. Without these measures, understanding battle management processes is not fully possible. This effort will be accomplished in two phases. The first phase will extend technology now used in operational evaluation and operations research, and incorporate advancements in CAD technology to identify newly distributed decision-making analysis methodology. The second phase will be to develop training/exercising methods to teach these skills and provide design guidance for systems to support distributed operations. The measures will be integrated with both large and small computer simulations now being used to train tactical C^2 personnel. Products re-

sulting from this work will include: (a) complex information-processing/decision-making analysis methods, (b) embedded performance recording and assessment techniques, (c) design guidance for new decision-aiding systems, and (d) prototype/training data base demonstrations.

(3) Design Guidance and Evaluation. Models will be developed to describe the internal information process (flow) for selected elements of C^2 systems to predict the impact that new, automated equipment and software will have on the C^2 process. Through an exploratory initiative (6.1) and an R&D consortium with the University of Dayton, Wright State University, and the AAMRL, R&D will be conducted to gain a better understanding of the limitations and capabilities of human C^2 operators. This R&D is necessary to perform concept definition work for software design, display technology, and systems intended to aid the decision maker. Later work will document and verify design guidance and standards for use by RADC and the Electronic Systems Division (ESD) to better match the characteristics of new C^2 hardware/ software systems with the capabilities of operators. The potential value of photographic-based visual imagery to improve tactical C^2 operations will be investigated. Work will initially focus on display requirements and use of overlaid graphics. It will continue with investigation of the actual utility of this technology for specific applications in mission planning, and comparisons with the effectiveness of current systems. Products resulting from the R&D on design guidance and evaluation include: (a) design data and recommendations for development, application, and evaluation of decision-aiding devices; (b) design data implications for the system operator of functionally distributed tactical C^2 operations; (c) human performance design data relevant to human memory capacity and automaticity; (d) predictive models of C^2 system processes; (e) user requirements analysis methods; (f) prototype system to assess human operator requirements; and (g) computer-aided human performance design tools.

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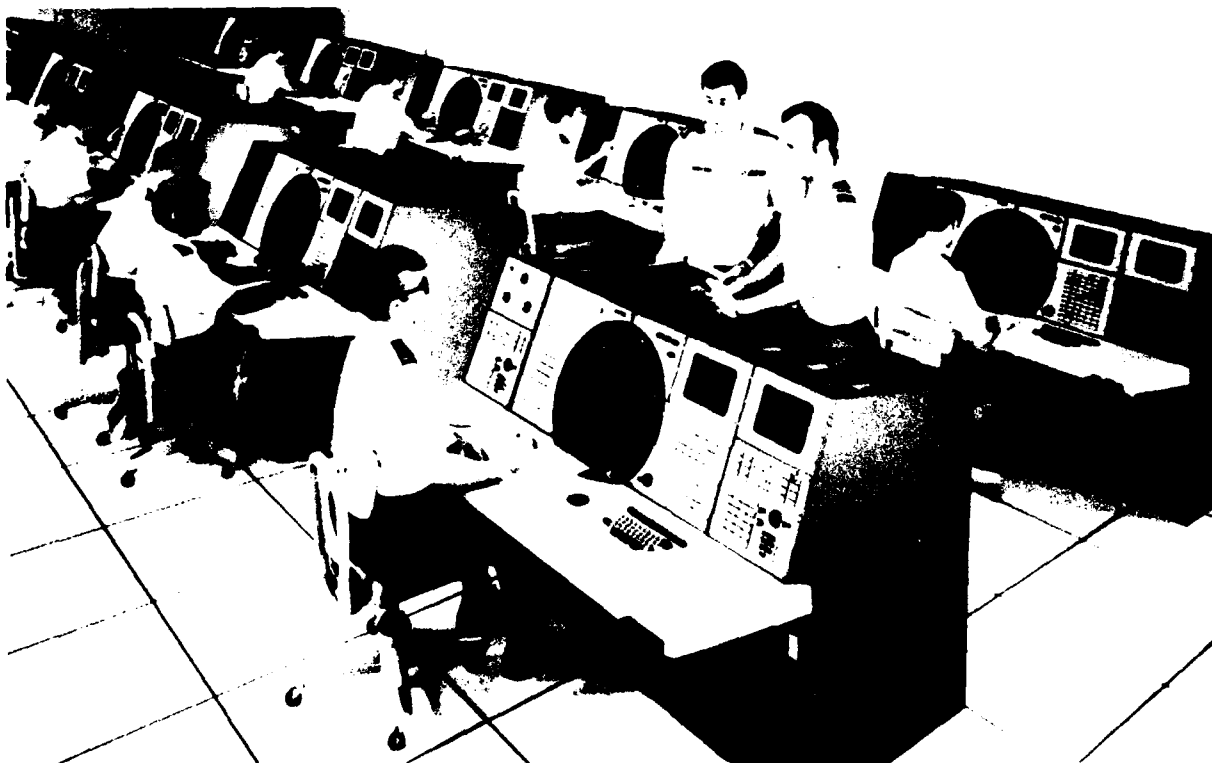Wright-Patterson AFB OH 45433
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Knowledge-Based C^2 Decision-Making Training

The effective use of air power is dependent on the performance characteristics of the aircraft and weapon systems, the ability of the support and air crews, and the expertise of the battle staffs and battle managers who control and direct these assets. One critical component of this capability is effective training for the battle managers and staffs within the tactical command and control (C^2) systems. This, in turn, demands a methodology to determine specific wartime training requirements and developments, tests, and demonstrations of training technologies capable of providing required training. The benefits of this R&D project would be realistic combat scenario exercises and training programs for personnel assigned to tactical C^2 systems.

The key to developing decision-making training is to first understand the performance and methods of an expert and then develop a system that trains the novice to think like an expert. Specifically, a training system is being investigated that repeatedly exposes the novice to prototypical situations and problems in his/her domain. This will allow the novice to develop the schema which underlie an expert's performance. This work is focused on the Air Support Operations Center (ASOC). Through a contract to Logicon, Inc., the Ground Operations Branch (LRG) will determine if expert systems technology can be used to develop decision-making training for battle managers. This R&D focuses on two major issues: (a) Can expert system and knowledge engineering techniques be used to make explicit the task knowledge employed by an expert battle manager? (b) Can the knowledge base developed by this technique be employed as a component of some form of computer-based training system?

Data collection on job performance skill requirements for fighter duty officers (FDO) assigned to a CONUS-based ASOC is underway. Prototype training program development will begin in FY88.

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Expert entering information during development of a training system

COMBAT LOGISTICS BRANCH (LRC)

In addition to the Integrated Maintenance Information System (IMIS) R&D program, the Combat Logistics Branch has several programs dealing specifically with the performance of maintenance personnel in a combat environment. It is expected that a future war would find maintenance technicians being subject to attacks on their work place. Some scenarios suggest that maintenance personnel may be required to perform their complex tasks in dispersed operating locations with limited personnel. Technological innovations are needed to help operational organizations perform under such conditions and to better evaluate their ability to plan for combat. In addition, techniques are needed to improve the performance of maintenance personnel under both combat and peacetime operations.

The recently completed (FY87) Combat Maintenance Capability (CMC) Study examined the differences between current maintenance of modern combat aircraft and future combat maintenance. The project focused on personnel performance, wartime usage rates, and evolving support concepts. It provided methodologies for evaluating current capabilities and predicting future combat capabilities.

Because it is anticipated that in future wars, combat aircraft may operate out of dispersed bases, the Small Unit Maintenance Manpower Analysis (SUMMA) effort is examining the impact of dispersal of air bases on manpower availability and developing alternative solutions to the problem. The project focuses on ways of expanding the job/task scope of existing maintenance specialties and evaluating personnel policies, training policies, and management initiatives that will facilitate the transition to a more broadly trained and capable work force.

It is well known that Soviet forces have a well-developed capability to use chemical weapons in combat. Air Force maintenance personnel must be prepared to operate under chemical warfare conditions. The Maintenance Limitations in a Chemical Warfare Environment Study is developing a methodology to evaluate maintenance capabilities in the event that chemical weapons are used. Products will include estimates of performance times, recommendations for modifications to the chemical defense protective suit, workarounds for difficult tasks, and recommendations for future R&D.

Technicians in protective chemical warfare clothing

Past experience has shown that serious losses can be expected from stress in combat situations. Since maintenance personnel will be expected to work under excessive stress, it is necessary to understand how the performance of technical tasks is impacted by the presence of combat stress. The Impact of Stress on Combat Maintenance Operations efforts will examine the feasibility of various approaches for reducing the impact of stress on maintenance. The approaches will be evaluated in terms of cost and potential payoff and the most promising approaches tested in a follow-on field test.

Each of the efforts described above will make a significant contribution to improving the ability of maintenance organizations to support combat operations. However, these efforts have been conducted and the products evaluated independently. It is essential that the technologies and the anticipated maintenance policies and structures work together effectively to support combat operations.

The Combat Planning and Attack Capability project is developing a plan to achieve and demonstrate the integration of the technologies described in the preceding paragraphs with the IMIS technology. The

demonstration will evaluate the capability of a maintenance unit to generate required sorties while operating under predicted combat conditions (using the previously described technologies). For the first time, we will have valid measures of the effectiveness of these new technologies and the ability of the test unit to support the combat mission.

Integrated Maintenance Information System (IMIS)

Changes in threats, support concepts, and weapon systems technology are taking place which will radically alter the way maintenance must be done to generate tactical sorties in future wars. Aircraft must be more dispersed. They must depend less on bulky test equipment and large on-site facilities for off-equipment maintenance. Systems will be more complex, more integrated, and require deeper maintenance on the line by fewer technicians who must master a broader range of tasks and skills. Automation will only increase the problem if introduced as a multiplicity of unique and incompatible information "aids." AFHRL is developing a comprehensive information and job-aiding system to help technicians generate the needed sorties in this environment.

The Air Force now has, or is developing, several computer systems for use at base level to support maintenance and supply functions. Unless integration occurs, the Air Force of the future will have several incompatible computer systems on the flight line, with continuing update requirements for each. Confusion will occur with possibly incompatible hardware, data requirements, and required training. The IMIS development will integrate these existing and developing systems with a computer-based technical information system, adding diagnostic job aids to increase the ability of technicians to troubleshoot and perform a wide range of maintenance actions. A demonstration on a fielded weapon system (F-16 aircraft) will be completed in FY88. The IMIS will provide an inte-

grated approach to total weapon system maintenance. Technical data, training, diagnostics, management, scheduling, and historical data bases will be linked together, and a portable graphic display job aid will be developed to present the required information at the job site. Interfaces will be developed for aircraft computers and for existing and emerging data bases.

Since 1976, AFHRL has conducted R&D to develop the technology for the presentation of technical data on an automated system. The emphasis was placed upon designing technical data presentation techniques and procedures tailored to meet the technicians' needs and make it easier for them to do the job. Emphasis was placed on developing data access techniques which make it easy to locate the information and developing presentation formats which make it easy to use the information. Experienced maintenance personnel from operational units have been and continue to be involved in all phases of the program (as consultants and test subjects) to ensure that the needs of the maintenance technician are met and that the techniques developed are suitable for use in actual maintenance operations. This prior work will now be further developed, fully integrated, and tested in a complete IMIS demonstration. This contractual effort has four phases: system functional requirements analysis; system design; prototype development and fabrication; and demonstration and field evaluation. The final product will be draft military specifications which describe the functional requirements of IMIS and outline how to adapt IMIS to various weapon systems and maintenance concepts. The specifications will include information format, content, and display requirements for the technical orders, diagnostic, training, and management information. Most importantly, the specifications will define the human factors and human-machine interface requirements for the system.

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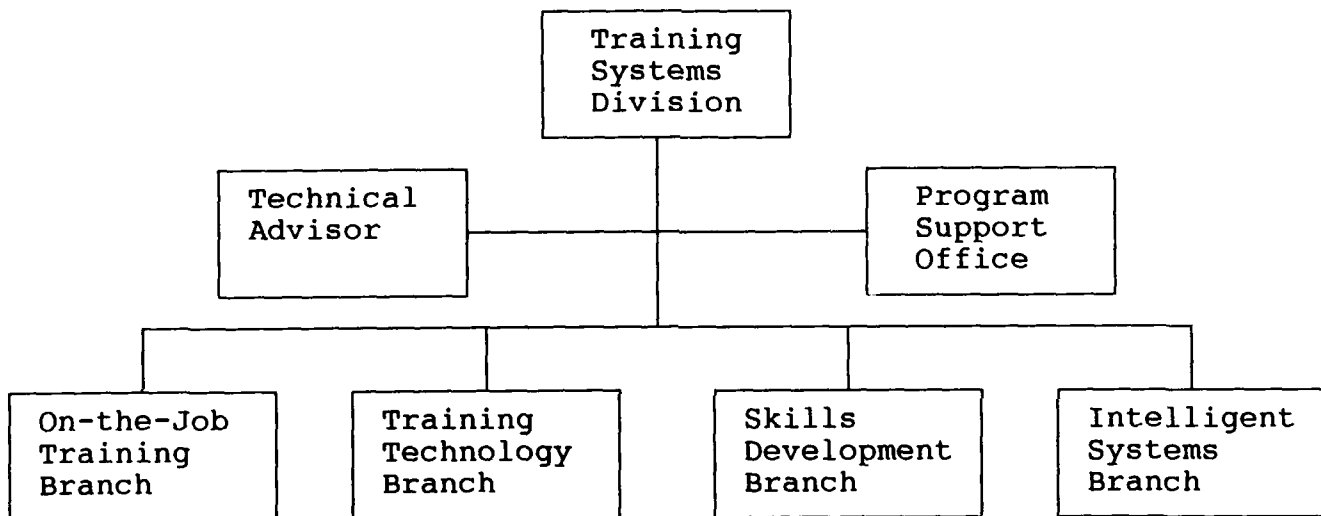Commercial: (513) 255-2606
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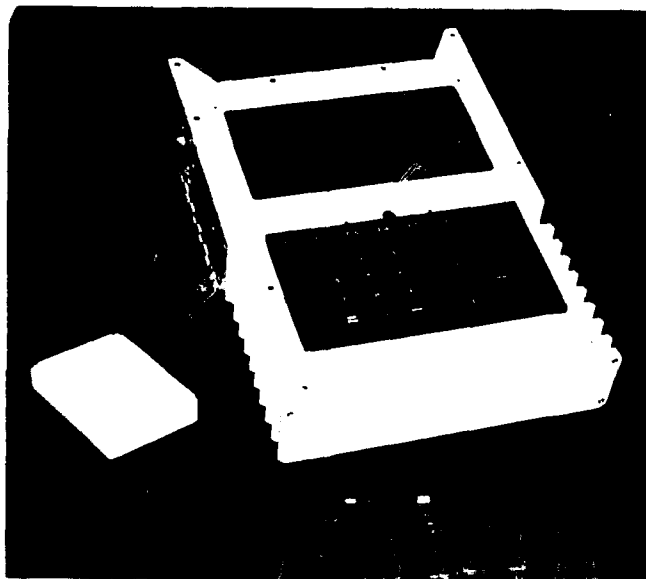
Prototype PCMAS unit along with one of the data cartridges that would be plugged in by the technician using the unit as an aircraft maintenance aid or diagnostic tool.

TRAINING SYSTEMS DIVISION

The Training Systems Division completed a move from Lowry AFB, CO to Brooks AFB, TX at the close of 1986. All Division personnel are now at Brooks AFB or at the operating location at Bergstrom AFB near Austin, TX. The primary objective of the Training Systems Division is to perform R&D to enhance Air Force skills development and job performance through improved training design, delivery, evaluation, and management. In addition, the Division has been designated the primary Laboratory center for artificial intelligence R&D, and in particular, its application to Air Force training.

To better accomplish the R&D mission, the Division has been reorganized into four branches, each named for its R&D thrust—the Training Technology Branch, Skills Development Branch, Intelligent Systems Branch, and the On-the-Job Training Branch. The revised Division organizational chart follows:

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                    │  Training    │
                    │  Systems     │
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The Division's R&D efforts are currently focused on seven major projects or thrusts:

| Branch	Projects
Training Technology	Computer-Based Training R&D Instructional Support System
Skills Development	Job Performance Measurement Training Decisions System
Intelligent Systems	Tools for Applying Artificial Intelligence to Training Intelligent Tutoring Systems
On-the-Job Training	Advanced On-the-job Training System

TRAINING TECHNOLOGY BRANCH

The Branch develops training technology that will contribute to the increased combat capability of the Air Force. The Branch's current program focuses on enhancement of the Instructional Support System (ISS), a versatile, state-of-the-art software system for designing, developing, delivering, evaluating, and managing computer-based training.

The strategic plan for future R&D broadens the Branch's focus on training technology. It will examine a large variety of user issues concerning training software transportability, reliability, maintainability and supportability. Key among these issues are improved training development, delivery and management software capabilities, and decision methodology for matching available computer-based training systems to user needs. The overriding strategic goal is to establish the Laboratory as the Air Force's center of expertise for the application of computer and computer-related technologies to Air Force training.

Instructional Support System (ISS)

The advent of computer applications to training has led to a multiplicity of hardware and software systems. Proprietary rights, vendor and machine dependence, and lack of software and courseware transportability were inevitable consequences. These factors have tended to keep the acquisition and life-cycle costs of commercial systems high and, as a result, inaccessible to many potential Air Force users. The approach in developing the ISS was to eliminate, or at least minimize to the extent feasible, the effects of these variables. The end result is a Government-owned, Ada software package for computer-based training that is machine and operating system independent, and that is easily modifiable to permit incorporation of future hardware and software advances. The ISS can be used to address a training requirement without being dependent on a particular vendor-supplied hardware/software pack-
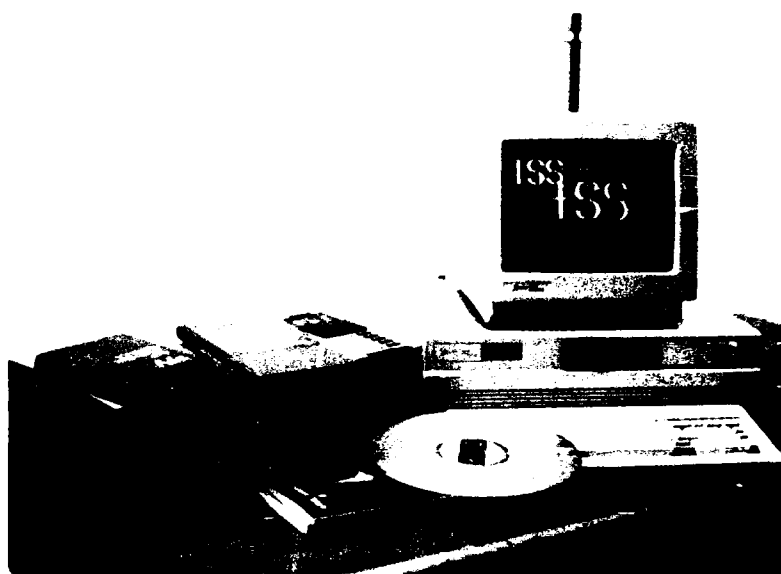
The demand for ISS is extensive.

age. Also, the users can tailor the system, through its modular design, to their unique needs rather than having to restrict or modify their requirements to fit the system.

The Air Force accepted ISS as a prototype on the VAX 11/780 minicomputer in October 1985. The Strategic Air Command at Dyess AFB, TX has served as the system testbed using ISS to develop, deliver, and manage 170 hours of online courseware to train 350 B-1B pilots and navigators.

In addition to operating on the VAX 11/780, 11/785 and 8600, the ISS was rehosted during FY87 to the MicroVax II. Videodisc capability was added and a

compact Micro Computer-Managed Instruction (CMI) capability was developed for microcomputer implementations. Exportable online and offline training courses have been developed for the Computer-Assisted Instruction (CAI) and CMI subcomponents of ISS. ISS is being rehosted to the Zenith 248 (Air Force standard) microcomputer, which will greatly expand ISS accessibility to Air Force users. The rehosting of the instructional software portion of the ISS was completed in December 1987, with the authoring portion following in early spring 1988. Training management will be rehosted in FY89. A transition plan is being finalized to move ISS from the laboratory environment to a long-term support agency. Data structure, data base and within-code application software documentation were developed to aid in transitioning the ISS to a long-term support agency. Transition of the VAX-based ISS to the Human Systems Division for full-scale development is planned during FY88, to be followed in FY89 by the Z-248 version.

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SKILLS DEVELOPMENT BRANCH

This Branch conducts R&D to improve training planning, the evaluation of training, and the acquisition of job skills through training. Presently, these programs include: (a) the Training Decisions System (TDS), a computer-based decision system enabling training managers to optimize training planning, programming, and budgetary decisions; and (b) the Job Performance Measurement System, a technology for collecting accurate and reliable job performance information which may be used to evaluate and improve the selection, classification, and training of airmen. Future programs will include R&D to enhance the way Air Force training is developed and conducted.

Job Performance Measurement (JPM)

The Job Performance Measurement (JPM) R&D program is developing a technology to objectively measure the job performance of airmen. This R&D program will provide cost-effective job performance measurement procedures that can be used to collect performance information for setting enlistment and classification standards or developing and evaluating training. This technology will help improve the match between people and jobs throughout the Air Force and provide commanders and supervisors with personnel who possess the knowledge and skills required to accomplish the mission.

This R&D effort received its impetus from two basic areas. First, Congress requested the DOD to determine the relationship of the Services' selection standards (Armed Services Vocational Aptitude Battery) to on-the-job (OJT) performance, rather than to training performance. This request led to the formation of a joint-Service working group with members from the Army, Navy, Marine Corps, and Air Force research communities, and oversight provided by a National Academy of Sciences Committee. The second push for this research came from Air Training Command (ATC) and the Air Force Military Personnel Center. Their interest was in (a) improving the

ability to predict success in the Air
Force (i.e., identify the best perform-
ers) by integrating job performance
information into the selection and clas-
sification systems, and (b) assessing the
effectiveness of Air Force training pro-
grams and making modifications, where
needed, based on how well graduates per-
form on the job. Thus, the overarching
benefit of the Air Force JPM project is
a more efficient and cost-effective per-
sonnel accession and training system.

A goal of performance measurement
technology is to provide the Air Force
with more well-trained personnel.

Monitor evaluates hands-on
performance of jet engine mechanics.

Development of job performance measures
incorporates expert review from active-
duty personnel in Air Force specialties.

Performance measure-
ment technology uses
on-equipment, task-
level evaluations.

Currently, the Air Force JPM R&D effort
centers on the development of a Job
Performance Measurement System (JPMS) for
eight enlisted specialties. The JPMS con-
sists of hands-on work sample tests and
a variety of additional job performance
measures which could prove to be cost-
effective substitutes for the hands-on
measures. The most detailed, task-
oriented Air Force measurement technique
being developed for the JPMS is called
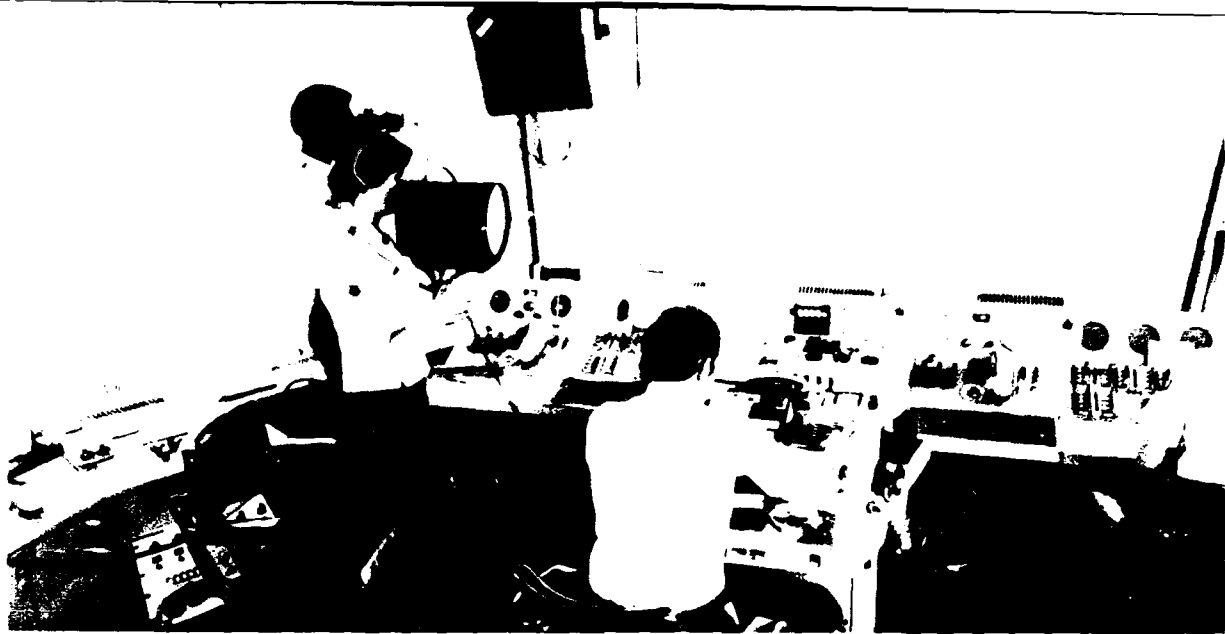
The JPM technology has also been applied to the area of training evaluation.

Walk-Through Performance Testing (WTPT). The WTPT is comprised of two major components: observation of actual hands-on performance and interview testing. Interview testing is designed to approximate a hands-on assessment as closely as possible, by using a "show and tell" procedure at the work site.

Although the hands-on portion of the WTPT gives the best measure of an airman's actual job proficiency that is currently possible, such testing is expensive and time-consuming. Thus, several other alternative measures to interview testing are being developed as part of the JPMS. These "surrogates" are gauged against the hands-on measure in terms of their cost effectiveness and the validity of the information they provide. The surrogates currently being developed include rating forms and written knowledge tests. After an extensive period of testing and revision, the JPMS for each AFS will be administered by highly trained enlisted personnel selected because of their expertise in the particular specialty.
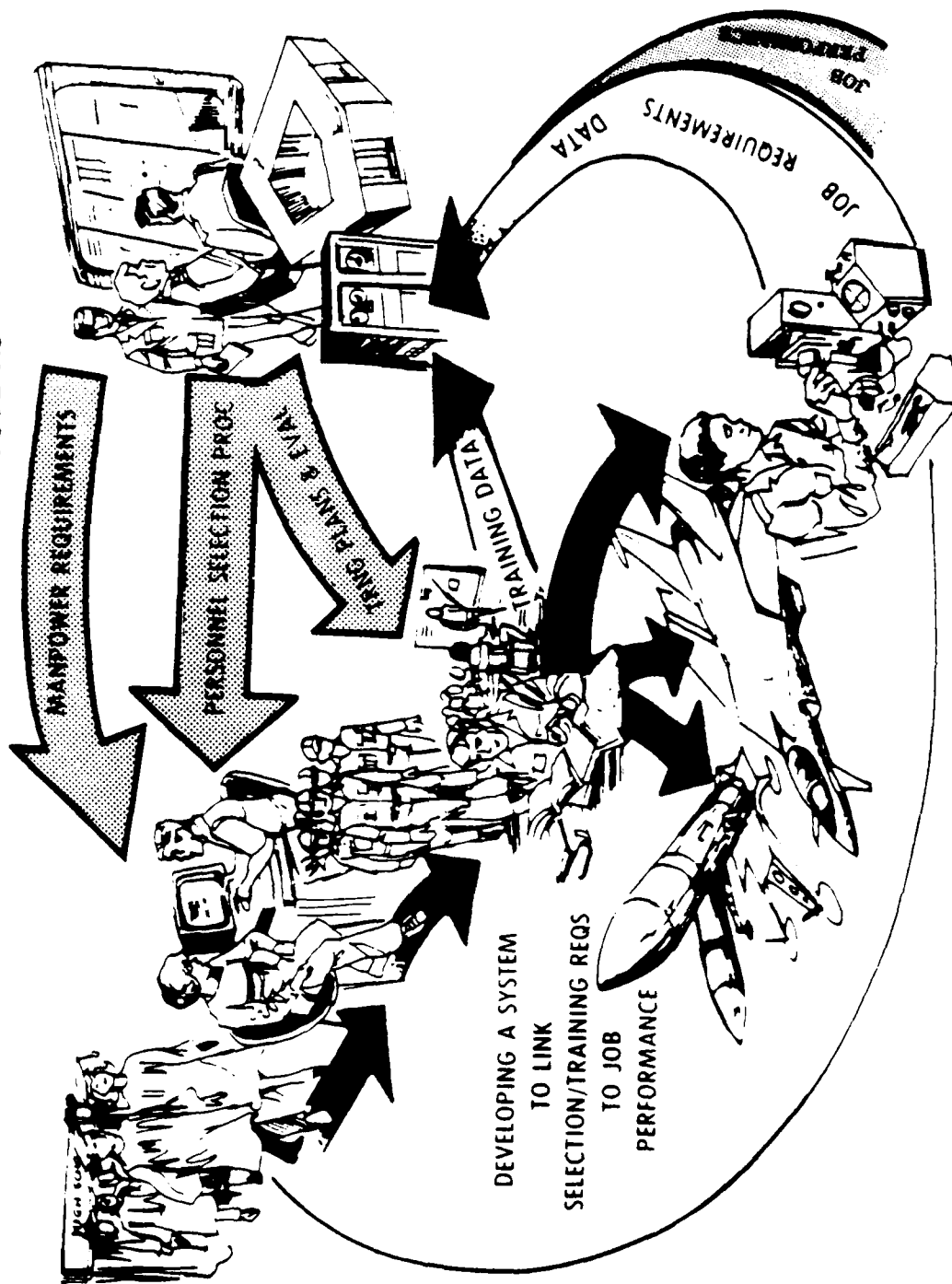
In FY87, the JPM R&D accomplishments included (a) analysis of data in one enlisted specialty and data collection in four others, (b) development of JPM instruments for four additional enlisted specialties, and (c) transfer of the Army technology to develop job knowledge tests in four Air Force enlisted specialties.
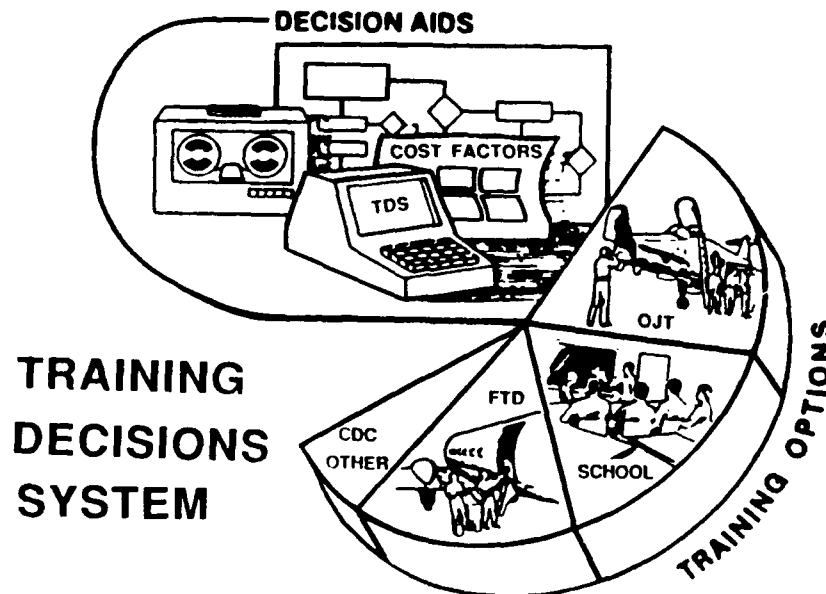
Although the major focus of these accomplishments has been to develop a performance measurement system that enhances selection and classification decision making, the JPM technology has also been applied to the area of training evaluation. One effort that demonstrates this is support of the ATC and TAC 4-Level Training Initiative to increase the initial weapon-specific training for jet engine mechanics. The JPM technology has been used to develop written and performance tests to evaluate the effect of additional resident technical training compared to current field training detachment and on-the-job training. In a similar way, JPM project knowledge and experience are being relied upon by HQ ATC to make improvements in their instructor evaluation program.

In FY88, a "hands-on" job performance measurement technique will be developed, evaluated, and compared with other measures of on-the-job performance. A follow-on to this effort will develop specifications for cost-effective performance measurement technologies. Data collected by using these techniques will be used to evaluate training and selection procedures. This work will be completed in FY92.

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PERSONNEL ASSESSMENT SYSTEMS

MANPOWER REQUIREMENTS

PERSONNEL SELECTION PROC

TRNG PLANS & EVAL

TRAINING DATA

JOB REQUIREMENTS DATA

JOB PERFORMANCE

DEVELOPING A SYSTEM TO LINK SELECTION/TRAINING REQS TO JOB PERFORMANCE

DECISION AIDS

COST FACTORS

TDS

TRAINING DECISIONS SYSTEM

OJT

FTD

CDC OTHER

SCHOOL

TRAINING OPTIONS

Training Decisions System (TDS)

Training decisions in the Air Force have become increasingly critical due to budgetary and manpower resource constraints. Historically, the Air Force has only been able to <u>retrospectively</u> evaluate the costs and benefits of different training alternatives. The Training Decisions System (TDS) will promote a more comprehensive and integrated approach to training programming and planning by providing Air Force manpower, personnel, and training managers with a computer-based, decision-making aid to identify and evaluate training alternatives for Air Force specialties (AFSs).

Due to the scope and complexity of Air Force training, the challenges faced by the Manpower, Personnel, and Training (MPT) communities deal with deciding <u>what</u> to train (training content decisions), <u>where</u> to train (appropriate settings), and <u>when</u> training should occur (at various points throughout an airman's career). Such decisions would be significantly improved by using a computer-based system which could proactively analyze and provide answers to "what if" questions such as: (a) Which tasks in a given AFS should be trained together? (b) When in the career path for a given AFS should specific training be given?

and (c) For a given AFS, in what training setting (i.e., Technical Training Center, OJT, or Field Training Detachment) is it most cost effective to train specific groups of tasks?

TDS is a multiyear R&D effort, consisting of developing three basic subsystems and a fourth integrating subsystem. The first subsystem, called the Task Characteristics Subsystem, identifies groups of tasks (training modules) and associated training site allocation preference data. These modules are the prime building blocks for other subsystems. The second subsystem, called the Field Utilization Subsystem, identifies alternative training/personnel assignment patterns. The third subsystem, the Resource/Cost Subsystem provides costs and capacity indicators for every task training module at each training site. These costs and capacity functions are an important input to the TDS's ability to evaluate the costs of different training alternatives. The fourth subsystem integrates the three previously described subsystems. This subsystem consists of optimization software and an interactive system, which permits training managers to ask a variety of "what if" questions.

Capt Jose Hernandez describes the Training Decisions System
to General Randolph (AFSC/CC), September 1987.

In FY87, TDS accomplishments included the development of (a) data collection methodologies, (b) procedures to determine current and alternative airman career patterns, and (c) modeling capabilities for determining effective training at minimum cost. In addition, a training/liaison program was established with the users to further the transition of TDS.

The TDS demonstrator is an interim microcomputer-based system designed to provide demonstrations and user evaluations of the TDS. The goal of the TDS is to provide training policymakers with advanced modeling capabilities to aid in developing optimal, overall training designs for enlisted Air Force career ladders. The TDS demonstrator provides potential TDS users with an opportunity to interact with and query the system to see how improved, cost-effective training decisions may be possible. The TDS demonstrator uses a combination of actual and simulated data to clarify the advantages that can be accrued from being able to answer "what if" training questions. The TDS demonstrator's ability to model such important factors as cost, assignment, and training capacity, and consider them early as an integral part of the Air Force training system development process, demonstrates how the Air Force may make more informed decisions by using the TDS. The TDS demonstrator is very user-friendly with its color displays, help screens, and diagrammatic representations. The menu-driven features used in the TDS demonstrator allow a manager with little or no computer background to see how the TDS would help develop the most cost-effective training possible while

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considering information about job tasks, assignment patterns, and managers' preferences.

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INTELLIGENT SYSTEMS BRANCH

The objective of the Intelligent Systems Branch is to perform R&D that improves the effectiveness of Air Force training through the application of Artificial Intelligence (AI) to advanced training systems. Three AI R&D thrusts provide a means for investigating scientific issues surrounding Intelligent Tutoring Systems (ITS): tools, tutors, and testbeds. Tools are used to acquire and represent knowledge to aid in the devel-

opment of ITS. The tutor thrust is concerned with designing and building prototype training systems to meet the user's needs. These systems are then used as testbeds for evaluating and assessing the cost and training effectiveness of ITS. The long-term goal is to build the best in ITS for the Air Force 2000 complex, high-tech jobs.

One cornerstone effort is the joint-Service project for a knowledge acquisition system and intelligent authoring aids. The purpose of this effort is to develop an ITS shell for joint-Service domains. Also, the intelligent authoring aids will allow an instructor, without computer experience, to develop a course of instruction in an automated tutoring situation. Currently, the branch is participating in a DOD-funded R&D project with the Army Research Institute (ARI) to determine the benefits of implementing ITS within the space training environ-

Artificial intelligence R&D will enhance training and instruction.

ment. An Associate Training Instructional Environment (ATIE) is a generic testbed for in-house R&D as the Branch looks toward the development of multiple domain intelligent training systems. For example, an in-house R&D effort on orbital mechanics has been developed for the Undergraduate Space Training School at Lowry AFB, CO. Major interest in such a project comes from HQ Space Command and HQ Air Training Command. For the long term, a four-year project called Intelligent Computer-Assisted Training Testbeds includes our more applied expert systems and ITS R&D projects.

Intelligent Computer-Assisted Training Testbeds

The approach adopted by this project is to acquire a library of modular software to enable rapid development of Intelligent Computer-Assisted Training. The approach reduces time and expense for developing instruction by providing instructional developers with kernel modules that can be adapted to specific instruction, and has the additional advantage of allowing the software to be easily updated to keep pace with changing technology. The project will then use this rapid development capability as a testbed within which to evaluate various instructional approaches in a range of Air Force occupations. Finally, the project will demonstrate the feasibility of developing cost-effective and instructionally effective intelligent computer-assisted training. The prototype software for this project is being developed under a joint-Service agreement with the Office of Naval Research.

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The goal of artificial intelligence in training is
to deploy high quality, individualized instruction.

The Intelligent Tutor for Space Operations program will demonstrate and evaluate Intelligent Training System technology in an Air Force training environment.

Intelligent Tutor for Space Operations

The Intelligent Tutor for Space Operations (ITSO) is an AFHRL-led project sponsored by the Joint-Services Committee on Manpower and Training Technology Development (JS/MTTD). The objective of ITSO is to design, implement, and evaluate a prototype intelligent tutoring system (ITS) in a space operations domain. ITSO will be demonstrated and evaluated at the Space Training Squadron located at Lowry AFB in Denver, CO. This effort represents an excellent opportunity to develop, demonstrate, and evaluate an ITS in a real training environment. In addition to developing an ITS for a space training domain, major emphasis will focus on cost and training effectiveness issues. This project will produce a prototype ITS, a set of functional specifications to include a methodology report, training effectiveness data, ITS development cost report, and lessons learned from the ITSO project.

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Knowledge Acquisition/Intelligent Authoring Aids

This is a joint-Service initiative to design and develop intelligent computer-assisted instructional tools and techniques for system users (instructors and students). The project is in the third year of a four-year R&D effort, and will allow each of the three Services (Air Force, Navy, and Army) to more efficiently train their members on a wide variety of tasks. Probable domains include space operations and space vehicle maintenance. In the past year, symbolic and natural language interfaces have been developed. These attributes allow the instructors to develop materials which will be used by the system as it delivers intelligent, automated instruction.

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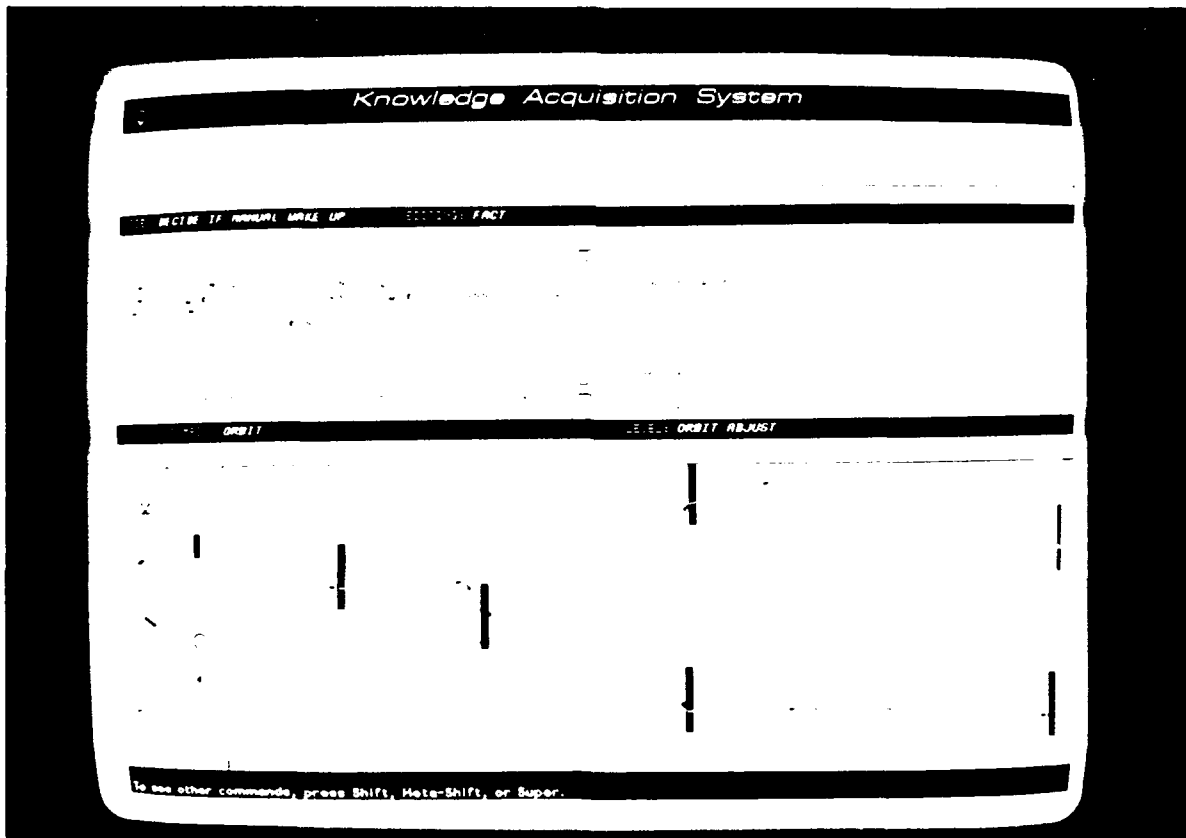
The Knowledge Acquisition/Intelligent Authoring Aids system is a joint Air Force, Army, and Navy effort to develop intelligent programming tools for building Intelligent Tutoring Systems.

## Maintainer's Associate Training Instructional Environment (MATIE I/II)

MATIE I was completed during FY87. A previously developed expert system was enhanced to permit the development of an Intelligent Tutorial System (ITS) based upon the maintenance knowledge domain. The objective of MATIE II is to implement and demonstrate the intelligent system based upon the ITS framework from MATIE I without the specific maintenance knowledge. A subobjective is to design a basic architecture called Associate Training Instructional Environment (ATIE). This would allow for the rapid development of an ITS for many domains.

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Intelligent Training Worlds

The Intelligent Training Worlds Program consists of research in alternative instructional approaches within ITS. In 1987, the orbital mechanics tutor (OMT) was completed. This intelligent tutor teaches the satellite ground tracks portion of the orbital mechanics course at the Undergraduate Space Training School, Lowry AFB, CO and features a graphics-intensive simulation of parameter-defined satellite ground tracks. The tutor has received the acclaim of Undergraduate Space Training School instructors. In 1988, the OMT will be implemented on Undergraduate Space Training School hardware for course delivery.

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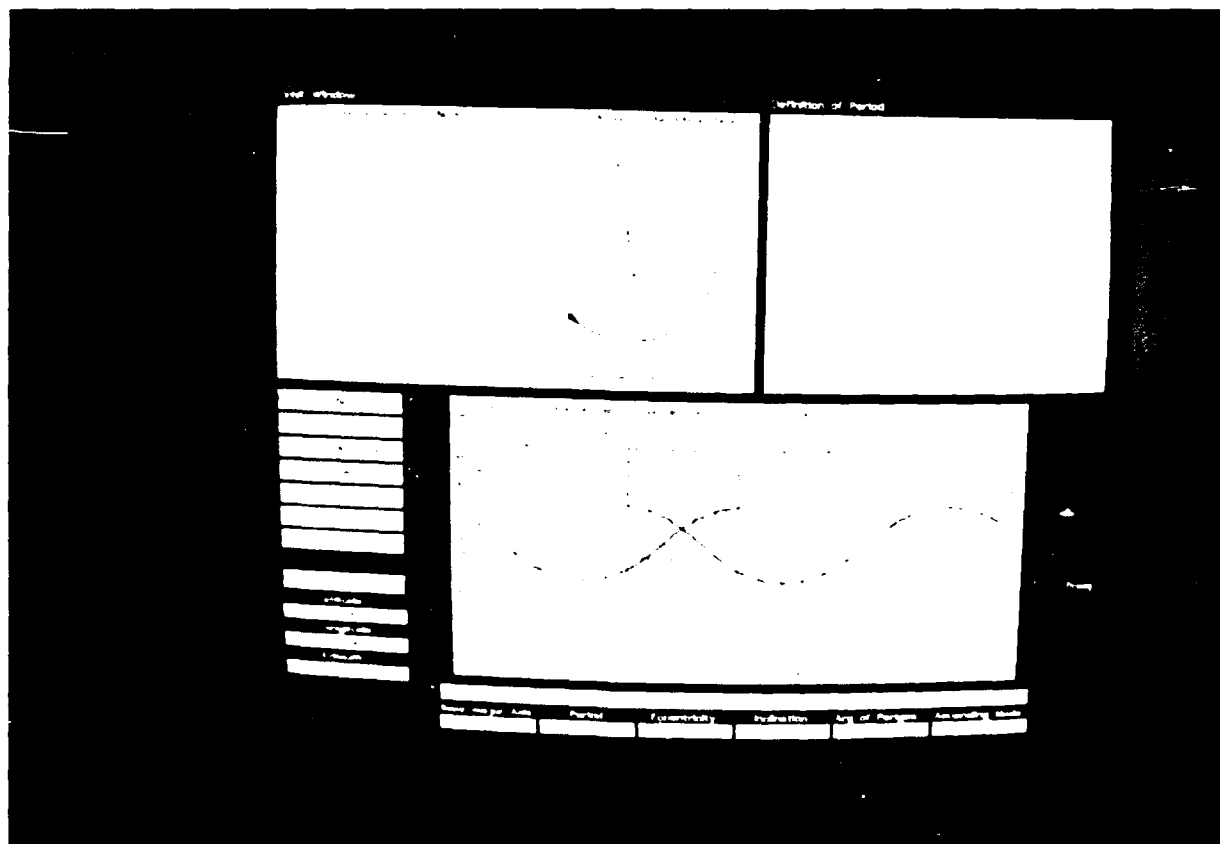
The orbital mechanics tutor offers very high-resolution graphics and a user-friendly interface.

ON-THE-JOB TRAINING BRANCH

The On-the-Job Training Branch is located at Bergstrom AFB, TX, a Tactical Air Command installation. Its mission is to develop a prototype system that can be used in the field to enable commanders and supervisors to conduct, manage, and evaluate on-the-job training in support of mission effectiveness. The Branch is located at Bergstrom AFB so that the prototype system can be developed, tested, and evaluated in the field.

Advanced On-the-job Training System

In the mid-1970's, functional management inspections, senior management reviews, and OJT studies and analyses have identified numerous operational deficiencies of job site training. While diligent effort has produced some improvement in OJT, major system deficiencies have continued to tax OJT capability, resulting in minimally effective job site training. In addition, new weapon systems, skills compression, and shortages of skilled technicians all increase the need for a system that is automated and capable of handling the Air Force's OJT needs. Consequently, the Air Staff directed an R&D effort to develop a prototype state-of-the-art Air Force OJT system.

The project objective is to design, develop, demonstrate, test, and evaluate a prototype Advanced On-the-job Training System (AOTS) for the Air Force that integrates and effectively manages, evaluates, and automates job site training. AOTS will provide the Air Force with capabilities to improve the methods for conducting and managing OJT, thereby making OJT more responsive to mission requirements.

System Level Test and Evaluation (SLT&E) is 12 months in duration, allowing the Air Staff and major commands to assess AOTS in the operational environment.

In addition to the evaluation data resulting from SLT&E, the evaluation plan calls for a side-by-side comparison of AOTS and current OJT system work centers. State-of-the-art technology will be systematically applied to OJT conducted in designated work centers of TAC's 67th Tactical Reconnaissance Wing, the 147th Fighter Interception Group of the Texas Air National Guard (Ellington ANGB), and the 924th Tactical Fighter Group of the Air Force Reserve. The enlisted job specialties used to develop the prototype system include: 426X2, Jet Engine Mechanic; 732X0, Personnel; 431X2C, Tactical Aircraft Maintenance; and 811XX, Security Police. AFHRL has 20 senior NCOs assigned to assist in the development of instructional and evaluation materials and to ensure the AOTS will work in the operational environment.

The AOTS prototype consists of five major interrelated subsystems that integrate Air Force training management, evaluation, training development and delivery, computer support, and personnel and logistics subsystems. The management subsystem improves OJT management tools and procedures at all levels of the OJT process. The evaluation subsystem provides evaluation materials, quality control procedures, and data for assessing OJT capacity and effectiveness. The training development and delivery subsystem provides AOTS with the additional capability to develop instructional materials and manage their delivery at the job site. The computer support subsystem applies state-of-the-art computer technology to support the management and evaluation of job site training. The personnel and support subsystem specifies the qualitative and quantitative personnel requirements of an operational AOTS, as well as the requirements associated with maintenance, reliability, logistics, and transition of the system.

The AOTS prototype development is a four-year, three-phased effort. The design phase fully details AOTS specifications and provides the design documents for the development phase. Phase II, the development phase, is the time during which AOTS will be built. The final phase,

The AOTS design phase was completed in May 1986 and the first set of software products containing training development tools was tested and delivered in June 1987. A contract modification to add the Training Development and Delivery subsystem to the AOTS contract was negotiated and work began in September 1987. Initial site surveys for the SLT&E at Bergstrom AFB and Ellington ANGB have been conducted. The AOTS team continues to work with the developers of other functional area automated systems to be aware and plan for system integration activities during field implementation. Planning for the SLT&E was started in January 1987; baseline data collection was initiated in October 1987, and will be continued until start of the test and evaluation period. The AOTS Senior NCO Instructional Systems Team has identified training requirements for the selected work centers, conducted task analyses, and developed behavioral objectives, and is developing training and evaluation materials in accordance with the Air Force Instructional Systems Development process. The AOTS software is scheduled to be completed in July 1989, and the SLT&E will take place from 1 August 1988 to 31 August 1989.

Transition planning with the Air Staff (HQ USAF/DPPES), and the Human Systems Division of Air Force Systems Command is ongoing and will continue throughout the project. A fully coordinated and signed technology transition plan is available for AOTS. Three levels of transition are required. AOTS has been designed to provide and emphasize the transition of incremental products, payoffs, and implementation as the work unfolds. Examples of initial products include: training requirements definition processes/lists, task proficiency evaluation procedures, training resources identification/ scheduling procedures, and automated training records. Incremental products will be provided to the Air Staff for evaluation and implementation Air Force-wide. The model AOTS at Bergstrom AFB, Texas is to be transitioned to the Tactical Air Command upon completion of the prototype. Finally, AOTS transition and implementation plans are to be provided to the Air Staff for deployment of AOTS throughout the Air Force.

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The Manpower and Personnel Division (MO) employs approximately 80 scientific, technical, and support personnel and has an annual budget of approximately $7 million to conduct research and development (R&D) in the areas of manpower, personnel, and training. The entire Division is located at Brooks AFB, except for approximately 10 people who operate an experimental testing program at Lackland AFB. The Division's work can be divided into three main thrusts: (a) measuring individuals' aptitudes and abilities, (b) determining job requirements, and (c) developing techniques for better integrating people and jobs. The Division is organized into the following four branches: (a) Force Acquisition (MOA); (b) Cognitive Skills Assessment (MOE); (c) Manpower, Personnel, and Training Technology (MOD); and (d) Force Management Systems (MOM). A Program Support Office (MOP) assists the task scientists in contracting, acquisition, funding, and other program control activities.

Most of the scientists in the Division are trained in the behavioral sciences, including psychology and human factors; computer science, mathematics, and operations research are also strongly represented. Seventy percent of the Division's scientists have advanced degrees with nearly one-third at the doctoral level.

The Division continues to be active in the joint-Service and international arenas. The Armed Services Vocational Aptitude Battery (ASVAB), used by all four Services for the selection and classification of all new enlisted members, is developed and maintained by MOA. The pilot selection technology developed by MOE is now being used operationally by the Air National Guard and is being evaluated by NATO and Australia, as well as the U.S. Army and Navy and Air Training Command. While the division has always maintained close ties with Air Training Command and the Air Force .ilitary
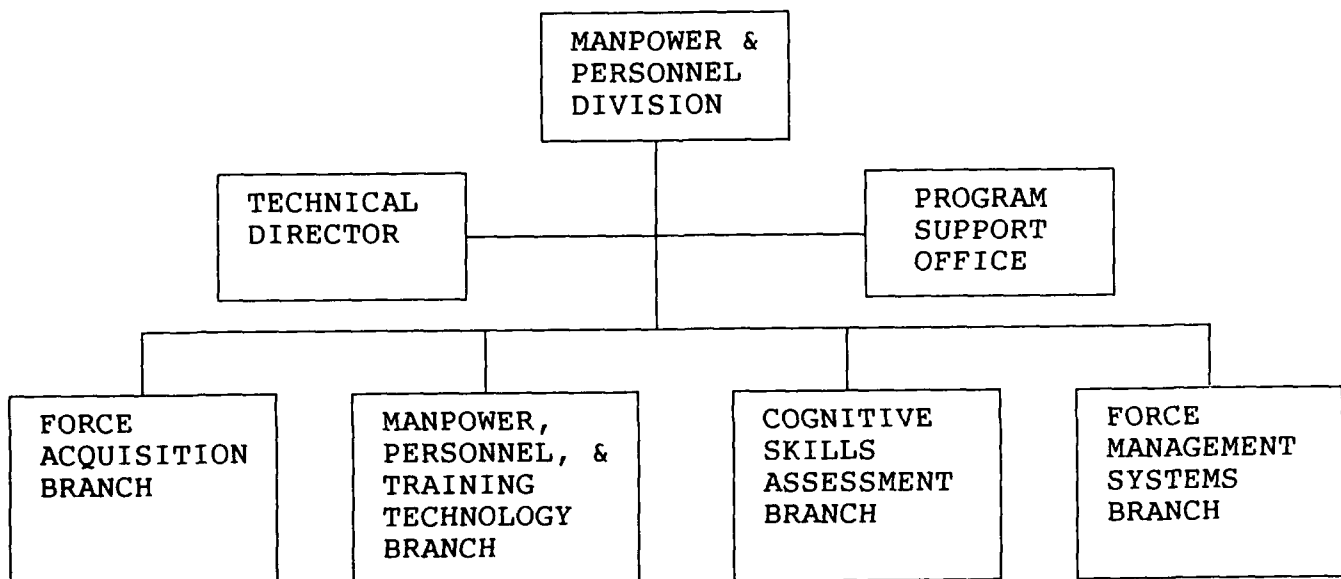
Personnel Center, it is also involved with other Air Force operating commands. The ongoing field test of a new Basic Job Skills tutor has involved Tactical Air Command (Langley, Eglin, and Holloman AFBs). Also, a methodology for enhancing productivity has been briefed to Pacific Air Forces and the Air Force Office of Security Police.

The Manpower and Personnel Division has a long history of valuable contributions to personnel management within the Air Force. In addition to ASVAB, the Division also developed the Air Force Officer Qualifying Test (AFOQT), the Weighted Airman Promotion System (WAPS), and the person-job match program used in the initial classification of all new Air Force recruits, and was a pioneer in the area of job analysis. During FY87, the Division delivered to HQ ATC/Technical Training a new classification algorithm which will be used to better assign basic trainees to their first career field. During the year, the Division also hosted a major conference on Manpower, Personnel, and Training (MPT) considerations in the Weapon System Acquisition Process (WSAP), an issue that is receiving increasing attention throughout DOD and the Congress and one that will demand a major R&D effort from the Division (and all of AFHRL) in the future.

FORCE ACQUISITION BRANCH

The Force Acquisition Branch conducts R&D on individual differences; develops measuring techniques and means for inclusion of these techniques into the operational selection/assignment system; conducts selection system research for Air Force military personnel by development and long-term validation of selection instruments and special-purpose aptitude batteries; accomplishes R&D in support of a tri-Service aptitude battery; prepares camera-ready copies of operational tests; and investigates the utility of new psychometric techniques.

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The ASVAB is used by all four Services
for the selection and classification of
all new enlisted members.

Armed Services Vocational Aptitude Battery (ASVAB)

The ASVAB is used as the primary enlistment selection and classification test for the United States Armed Services. The ASVAB is administered to approximately one million applicants for the U.S. military in the operational testing program, as well as another one million high school students in the DOD Student Testing Program. The Laboratory is the lead Service personnel R&D organization supporting the joint-Service and DOD programs. AFHRL not only develops the ASVAB forms for both programs, but also accomplishes the R&D necessary to support each testing system. Recently, AFHRL completed the operational calibration and the Initial Operational Test and Evaluation of the next generation of ASVAB forms (Forms 15, 16, and 17) due for implementation 1 October 1988. Additionally, AFHRL completed the construction and operational calibration of four new versions of the ASVAB to be used in the DOD Student Testing Program.

During the past year, AFHRL began development of military testing archives, and work was also begun on a revision to the High School Counselor's Manual that will incorporate additional information on the ASVAB that has been published since the previous 1984 edition. Work was completed on the Civilian Occupational Validity effort, as well as an item-level bias project for ASVAB Form 14 used in the DOD Student Testing Program. A number of analytic studies of the ASVAB were completed dealing with alternate forms reliability and operating characteristics of previous forms of the paper-and-pencil ASVAB, as well as an R&D effort on Multidimensional Item Response Theory models.

For the future, the Laboratory will be looking to further develop indices of "appropriateness" measurement by operationally testing these measures, using state-of-the-art psychometric advances in order to detect compromise and true and deliberate failures.

We will also look to complete a large-scale factor reference analysis of the ASVAB and begin development of the follow-on forms of the ASVAB for implementation in 1992.

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Air Force Officer Qualifying Test (AFOQT)

The Air Force Human Resources Laboratory (AFHRL) has the primary responsibility for the development of the AFOQT and R&D supporting its use. The test is the principal aptitude measure used in the selection of officer candidates for the Air Force Reserve Officer Training Corps (AFROTC) and Officer Training School (OTS) programs. The AFOQT is also used to classify commissionees for further training in technical fields, Undergraduate Pilot Training (UPT), and Undergraduate Navigator Training (UNT). Approximately 35,000 college students and graduates are administered the AFOQT each year. In 1987, AFOQT test results were used in selection and classification decisions for about 61 percent of the pilot selectees, 87 percent of the navigator selectees, and over 90 percent of the nonrated officer job assignments.

The primary benefit of the AFOQT is an enhanced Air Force capability to identify, from the large pool of civilian applicants, those candidates with a high likelihood for success as Air Force officers. Payoffs include reduced attrition in OTS, AFROTC, technical schools, UPT, and UNT. With the implementation of alternate AFOQT Forms (P1 and P2) this year, new benefits were realized. Applicant retesting capability was improved; risk of test compromise was also reduced. Should one test version be compromised, the second version can continue to be used exclusively with no interruption of operational testing.

UNITED STATES AIR FORCE

OFFICER QUALIFYING TEST

The most important R&D activity in this program is the constructing and transitioning of new versions of the AFOQT to the Air Force Military Personnel Center (AFMPC), the agency responsible for the operational testing program. Other critical R&D tasks are continual monitoring of test performance in the operational setting and test validation against selection system and training criteria.

During FY87, MOAO completed the analysis and documentation of a Forms P preimplementation project. Products delivered to AFMPC included final copies of Forms P test booklets, an administration manual, scoring keys, and interim conversion tables. Concurrent with Forms P implementation in June 1987, an Initial Operational Test and Evaluation (IOT&E) was begun. One goal of the IOT&E is to verify the raw score to percentile conversion tables developed from the preimplementation project. Another major product which was developed and transitioned recently was the AFOQT Information Pamphlet (AFPT 997, 01 January 1987).

An ongoing major effort of MOAO is the development of item pools for each of the current AFOQT content areas and for 13 new subtests. These will support development of the Forms Q. AFHRL is also continuing R&D in support of Forms P. This includes assessment of test performance, validation with OTS and AFROTC selection systems and training outcomes, validation against aircrew training criteria, and generation of an AFOQT "quick score" for recruiters. Plans are also underway to identify, develop, and validate new predictors of officer success outside the cognitive domain. Of special interest are managerial and leadership abilities.

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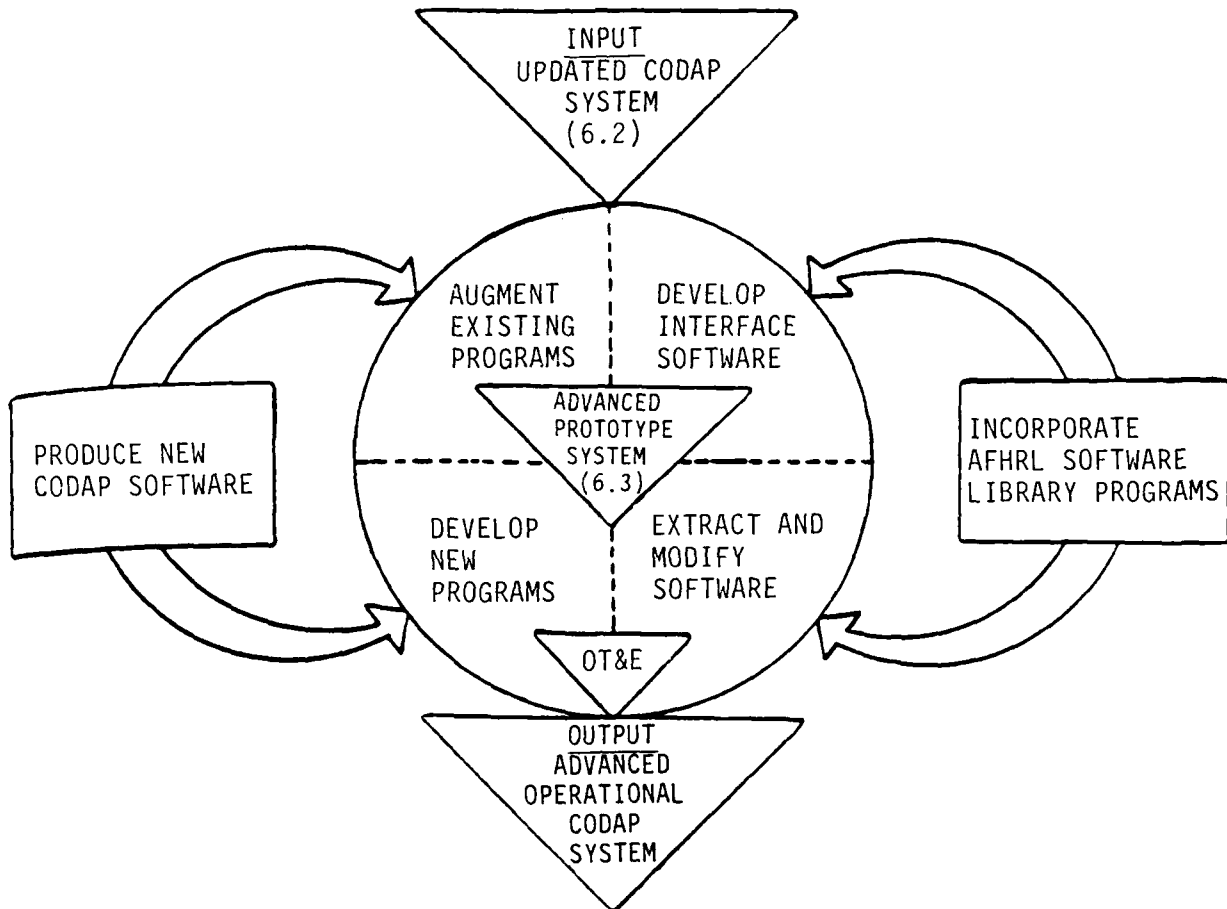## MANPOWER, PERSONNEL, AND TRAINING TECHNOLOGY BRANCH

The Manpower, Personnel, and Training Technology Branch develops methods for estimating manpower, personnel, and training needs of new and modified weapon systems. It develops methods for collecting, analyzing, and reporting data describing jobs and organizations. It develops methods/procedures for determining the mental, physical, and educational requirements of jobs. It also develops methods for estimating the availability of military personnel, and methods for estimating the ability of the Air Force to attract personnel from the civilian labor pool.

Occupational Measurement Technology

The principal occupational analysis technology in the Air Force is the Comprehensive Occupational Data Analysis Programs (CODAP) software system, which was developed in the early 1960s to resolve a variety of manpower, personnel, and training (MPT) management questions. Current CODAP development efforts (based on the new ASCII FORTRAN Standard) will result in increased system capabilities and advanced analytical features and technologies such as automated job-type selection procedures, profile analysis techniques, and non-hierarchical and semantic clustering capabilities. These enhancements will support important applications efforts by the USAF Occupational Measurement Center (USAFOMC), the primary user of the ASCII CODAP software, as well as numerous MPT-related R&D activities being conducted by AFHRL.

Included in the enhanced ASCII CODAP software are techniques to automate the Weighted Airman Promotion System (WAPS) Test Outline development procedures. As part of the WAPS, airmen eligible for promotion to the grades E-5, E-6, and E-7 are required to take a Specialty

ADVANCED DEVELOPMENT OF CODAP

```
                    INPUT
                UPDATED CODAP
                   SYSTEM
                    (6.2)


            AUGMENT  |  DEVELOP
            EXISTING |  INTERFACE
            PROGRAMS |  SOFTWARE
                   ADVANCED
PRODUCE NEW        PROTOTYPE        INCORPORATE
CODAP SOFTWARE      SYSTEM          AFHRL SOFTWARE
                    (6.3)          LIBRARY PROGRAMS

            DEVELOP  |  EXTRACT AND
            NEW      |  MODIFY
            PROGRAMS |  SOFTWARE

                    OT&E

                   OUTPUT
                  ADVANCED
                 OPERATIONAL
                    CODAP
                   SYSTEM
```

Knowledge Test (SKT), designed to test their knowledge of their career field. Automated procedures have been developed to enhance the validity of the Air Force test development procedures by providing a more direct link between job content and promotion test content. During the process, direct measures of testing importance are collected from senior level noncommissioned officers on selected sets of job inventory tasks. CODAP software is used to process these ratings and to produce a recommended number of SKT items to be written for task sets within major duty areas. Test developers use the individual task performance statements as aids in writing SKT items.

The final product of the CODAP effort will be a prototype occupational measurement software system which will be more responsive to the increasingly sophisticated methods and procedures required by Air Force occupational researchers

and analysts. As the official DOD methodology for conducting job analyses, the ASCII CODAP system should transition to the other branches of the Armed Services within the next year. Additionally, AFHRL will continue its involvement with Federal and state agencies, county-level governments, and universities as they obtain and use CODAP for their occupational analysis needs.
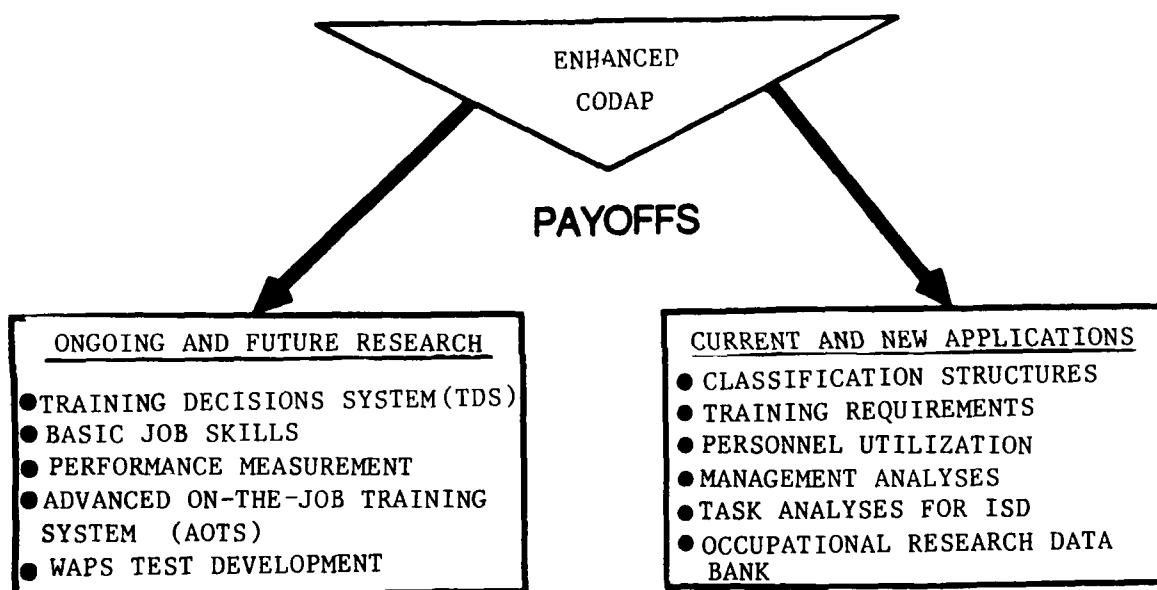
The graphic above depicts various aspects of the ongoing development of the CODAP system. The "arrowpoints" running from top to bottom focus on the ongoing effort to update and redesign the CODAP software to arrive at an advanced prototype software system for occupational analysis (to be completed by September 1988). The prototype system will facilitate a large-scale expansion of the CODAP system, as shown in the large circle surrounding it, in terms of augmenting existing

programs, developing new programs, extracting and modifying non-CODAP software for incorporation into CODAP, and developing interfaces with AFHRL software library programs. Simultaneously, OT&E of the new, modified, and interfaced software will be conducted, not only to ensure that the software is working properly for all types of CODAP data sets, but also to establish applicability criteria. The final output will be an advanced operational CODAP system (to be completed by September 1992).

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OCCUPATIONAL MEASUREMENT TECHNOLOGY

ENHANCED
CODAP

PAYOFFS

ONGOING AND FUTURE RESEARCH

- TRAINING DECISIONS SYSTEM(TDS)
- BASIC JOB SKILLS
- PERFORMANCE MEASUREMENT
- ADVANCED ON-THE-JOB TRAINING SYSTEM (AOTS)
- WAPS TEST DEVELOPMENT

CURRENT AND NEW APPLICATIONS

- CLASSIFICATION STRUCTURES
- TRAINING REQUIREMENTS
- PERSONNEL UTILIZATION
- MANAGEMENT ANALYSES
- TASK ANALYSES FOR ISD
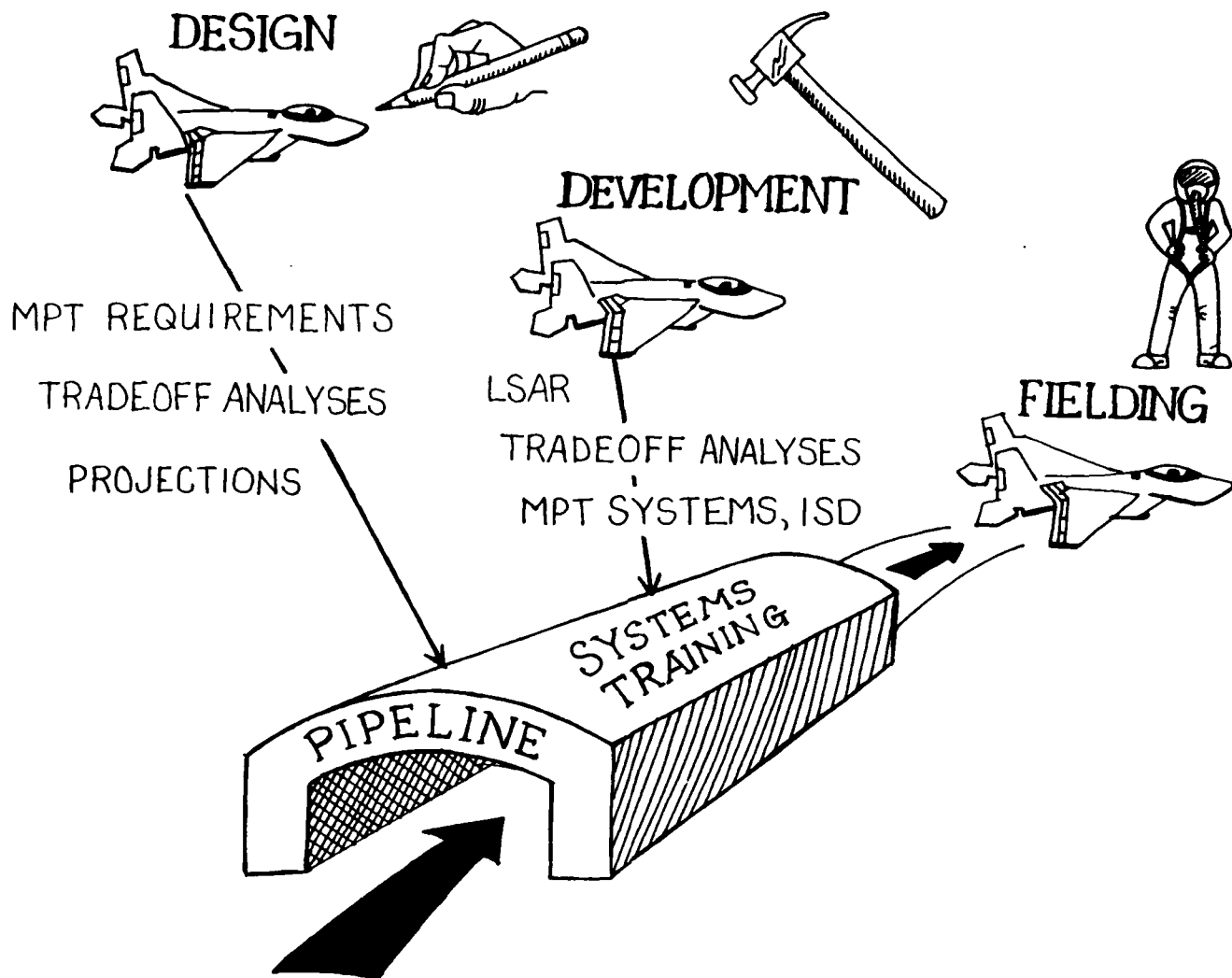- OCCUPATIONAL RESEARCH DATA BANK

Manpower, Personnel, and Training Integration Research

At a time when emerging weapon systems are requiring more highly skilled personnel, significant manpower authorization shortages and increasing industry competition for personnel with high technical skills mandate that manpower, personnel, and training (MPT) requirements be evaluated early and as part of the new weapon system design tradeoff decision process. Three problems hinder this effort. First, MPT requirements have little impact on design decisions. Second, fielding of new or modified weapon systems is suboptimal because the acquisition process does not provide detailed information sufficiently early to permit personnel and training pipelines to be properly established before delivery. Finally, for existing weapon systems, there are insufficient data base and software mechanisms for the MPT managers to consider total system impact when making specific decisions in their spheres of influence.

The MPT Integration Research Project will develop technologies to solve each of the three problems stated above. Both in-house and contract R&D will be used to modify existing and develop new MPT forecasting and integrating technologies. Specifically, extensive occupational analysis, task benchmarking, aptitude and training requirement forecasting, and job and force modeling technologies will be modified or developed to fill identified technology gaps. Interim products will be transitioned to MPT users for implementation as these products are completed. Technologies now nearing completion will aid the integration of MPT decisions for existing weapon systems.

Three efforts illustrate our work in the MPT arena during 1987: conducting an Air

DESIGN

MPT REQUIREMENTS

TRADEOFF ANALYSES

PROJECTIONS

DEVELOPMENT

LSAR

TRADEOFF ANALYSES

MPT SYSTEMS, ISD

FIELDING

PIPELINE   SYSTEMS TRAINING

Manpower, personnel, and training requirements must
be evaluated early in weapon system design process.

Force-wide MPT conference, completion of
a Logistic Support Analysis-Instructional
Systems Development (LSA-ISD) interface
system for the C-17, and progress in the
area of weapon-system-specific job analy-
sis. Each of these efforts warrants
further comment.

First, AFHRL held an MPT conference on
11-13 May 1987, which brought together
the acquisition, design, development, and
user communities with the manpower, per-
sonnel, and training communities so that
they could jointly determine what tools
and technologies are available and needed
to successfully integrate MPT decisions
into the Weapon System Acquisition Pro-

cess (WSAP). The approximately 200
attendees included representatives from
user and support major commands, Air
Staff, the System Program Offices (SPOs),
contractors, the R&D community, etc. The
conference provided interaction opportun-
ities for key MPT players to establish a
common frame of reference, to bridge
communication gaps, and to establish
policy and R&D issues for future MPT
program direction. The conference pro-
vided the participants with a unique
opportunity for interaction and a chance
to surface critical issues and problems.
AFHRL will be able to develop a compre-
hensive R&D plan aimed at providing a
better coordinated MPT decision process

to be integrated into the WSAP. All agencies will be able to use conference documentation to plan MPT-related initiatives in individual and Air Force-wide efforts.

The second effort is the C-17 Logistic Support Analysis-Instructional Systems Development (LSA-ISD) interface. This program was initiated to provide contract support to the 3306 Test and Evaluation Squadron (TES) for initial developmental efforts to automate the design and analysis phases of the ISD process. The 3306 TES (ATC) will be the user of the prototype ISD system. AFHRL/MO will use the knowledge gained in training R&D on other new weapon systems. Objectives of the LSA-ISD interface are to provide the 3306 TES with accelerated development of C-17 training materials and advanced definition of Air Force ISD needs for new weapon systems.

The effective maintenance of complex systems is dependent on the technical training of the personnel charged to maintain them. Current training for new acquisitions is deficient because of the cumbersome process of identifying initial requirements. This process involves manual processing of voluminous Logistic Support Analysis (LSA) data, engineering drawings, and data supplied by the system developer. There are also frequent changes as the system develops, and numerous problems in translating these changing data into training materials. An automated system is needed to expedite the entire procedure; provide convenient and rapid means to locate, match, and update the changing LSA and engineering data; and reformat them both into products convenient for ISD. The need is especially pressing for the 3306 TES at Edwards AFB, the unit developing training materials for use at field training detachments (FTD) for the Douglas Aircraft C-17. Since this aircraft is in the production phase, the 3306 TES needs an off-the-shelf computerized system to expedite their ISD effort. The prototype interface was demonstrated

in October 1987 at Edwards AFB for individuals representing the training technology area from each of the three military Services. The prototype interface was completed and presented to the 3306th TES at that time, along with a final set of functional specifications for the software development.

The third effort concerns weapon ·system specific job analysis. This R&D effort is designed to develop task identification and analysis methods that can be used to forecast tasks and task performance requirements for emerging weapon systems. To accomplish this objective, the attempt is being made (a) to link existing task identification/analysis data bases, (b) to use data resulting from these linkages to develop weapon-system-specific job inventories, (c) to develop improved procedures to analyze new inventory data, and (d) to apply these new data to address MPT-related issues/problems.

To date, the following three tasks have been accomplished. The first was a scientific evaluation of the validity and reliability of five task-level data bases: Logistics Composite Model (LCOM), Maintenance Data Collection System (MDCS), Logistic Support Analysis (LSA), Occupational Survey (OS) data, and Instructional Systems Development (ISD). Included in this evaluation were tasks measured by different methods and their application, method of data collection, and where and how data are maintained. The second task focused on user needs assessment in the areas of acquisition, personnel management, training, and combat. The third task dealt with linkages between the MDCS and OS data to account for LCOM skill level tradeoffs.

This project is in the early stage of developing data bases, technologies, and procedures needed to insert MPT tradeoffs into weapon systems planning and design activities to improve supportability, reduce life-cycle costs, and aid weapon systems fielding.

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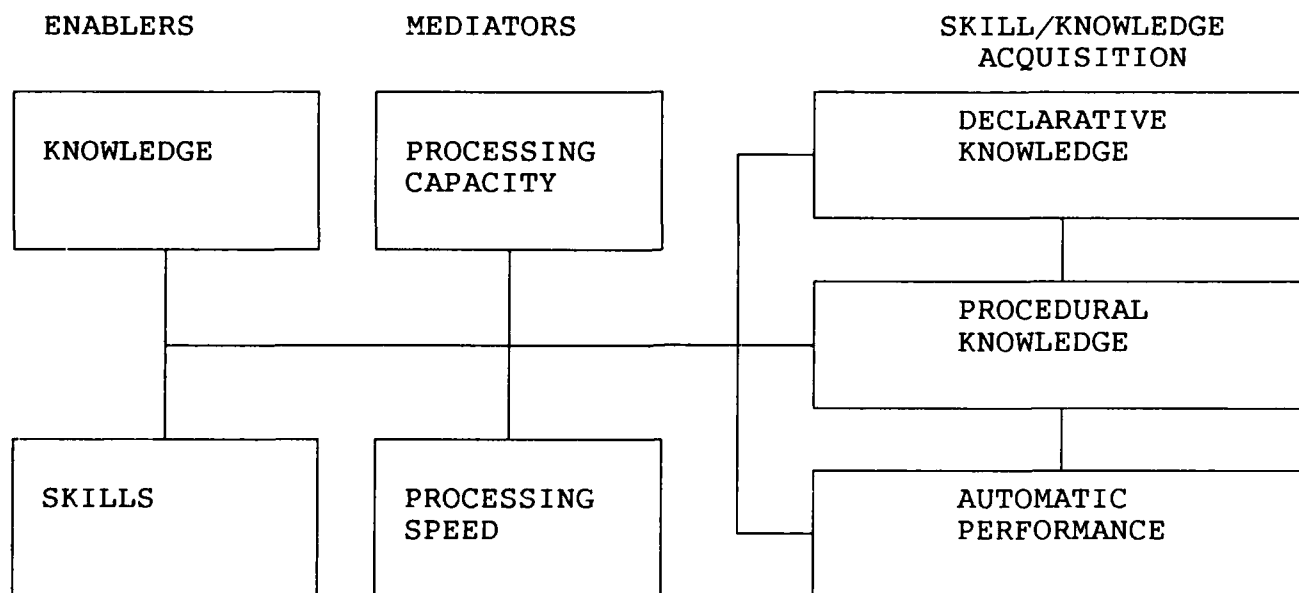
COGNITIVE SKILLS ASSESSMENT BRANCH

This Branch designs and executes laboratory experiments to identify basic cognitive skills, such as parameters of learning ability. It investigates relationships of these skills to Air Force training and job performance to identify new measures for improvement of Air Force selection and classification test batteries and procedures. It identifies such candidate measures and procedures to the Force Acquisition Branch for incorporation into operational systems. The Branch develops and maintains an automated testing laboratory necessary for these studies. It provides experimental data collection services for both computer-based and paper-and-pencil testing for other division programs.
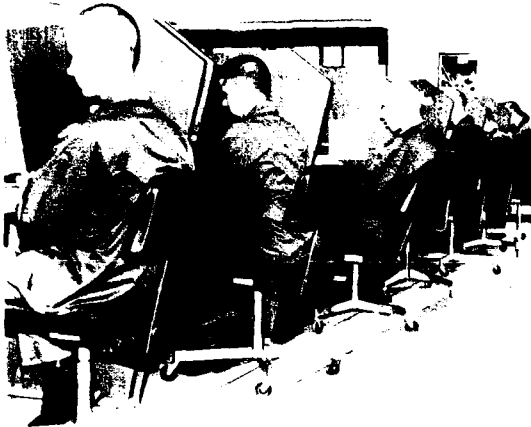
The Learning Abilities Measurement Program (LAMP)

LAMP is a major research effort in cognitive science that is jointly sponsored by the Air Force Office of Scientific Research (AFOSR) and AFHRL. It is supported by facilities at Lackland AFB which house 30 microcomputer testing stations and 30 artificial intelligence work-stations for delivery of intelligent computer-assisted instruction. Approximately 300 airmen in basic military training are available as subjects each week, and over 50,000 have participated in testing conducted to date.

There are two major objectives for the LAMP effort: first, to identify the basic components of human cognition; and second, to determine how well complex knowledge and skill acquisition can be predicted by some combination of these components. The first objective has been pursued since 1984. It is hypothesized that individual differences in knowledge and skill acquisition can be accounted

PROJECT LAMP RESEARCH FRAMEWORK

ENABLERS	MEDIATORS	SKILL/KNOWLEDGE ACQUISITION
KNOWLEDGE	PROCESSING CAPACITY	DECLARATIVE KNOWLEDGE
		PROCEDURAL KNOWLEDGE
SKILLS	PROCESSING SPEED	AUTOMATIC PERFORMANCE

Basic trainees participate in LAMP program.

LAMP investigates the nature and organization of human learning abilities, with the ultimate goal of contributing to a new model-based selection and classification system for the Air Force. LAMP research conducted thus far has resulted in a tentative model of the mental skills responsible for the ability to learn. The model states that an individual's skill and knowledge levels vary along four major dimensions: working memory capacity, information processing speed, factual knowledge, and procedural or strategic knowledge. The model also assumes that these four source skills interact. The importance of having a model of learning ability is that the model can suggest means for constructing new kinds of ability tests, and can also serve as the basis for new task analysis systems. The model will eventually help specify what kinds of cognitive skills ought to be measured in order to develop equations for predicting the likelihood that a person will succeed in training and on the job.

for by two major categories of cognitive components: Enablers, which include all the conceptual knowledge and skills the learner has upon entering instruction; and Mediators, which include processing capacity and processing speed. In pursuit of the first objective, experimental tests are designed to assess cognitive components using microcomputers and are subjected to detailed internal analysis to determine if the desired ability is indeed being measured. Groups of tests assessing cognitive components are administered in batteries along with knowledge and skill acquisition criterion tasks to obtain an initial idea of the predictive power of the new tests.

R&D addressing the second objective is just getting underway. Intelligent tutoring systems are being developed to teach skills in electronics, computer programming, and flight engineering. Indicators of learning progress will be obtained from these tutors and will serve as criteria against which experimental tests developed in LAMP can be validated. The eventual goal is to cover the entire course of skill acquisition, from learning the basic declarative knowledge needed for skill execution, through proceduralization of that knowledge, to eventual automatization of the skill.

The LAMP effort is currently staffed by four in-house scientists. Their expertise in cognitive science is augmented by that of university scientists who participate in a special grant program established by AFOSR. AFHRL provides testing support and Air Force subjects to university scientists who wish to contribute to the LAMP research objective.

Proctor monitors LAMP testing program.

Although this program is devoted to basic research, usable outcomes are anticipated. For example, a major goal is to develop new ability measures for inclusion in future personnel selection and classification programs. As in any basic research program, however, it will be a number of years before the contribution of LAMP is fully known. But the results of early studies and the vision of ultimate success have already generated excitement in the scientific community, as well as in AFHRL.

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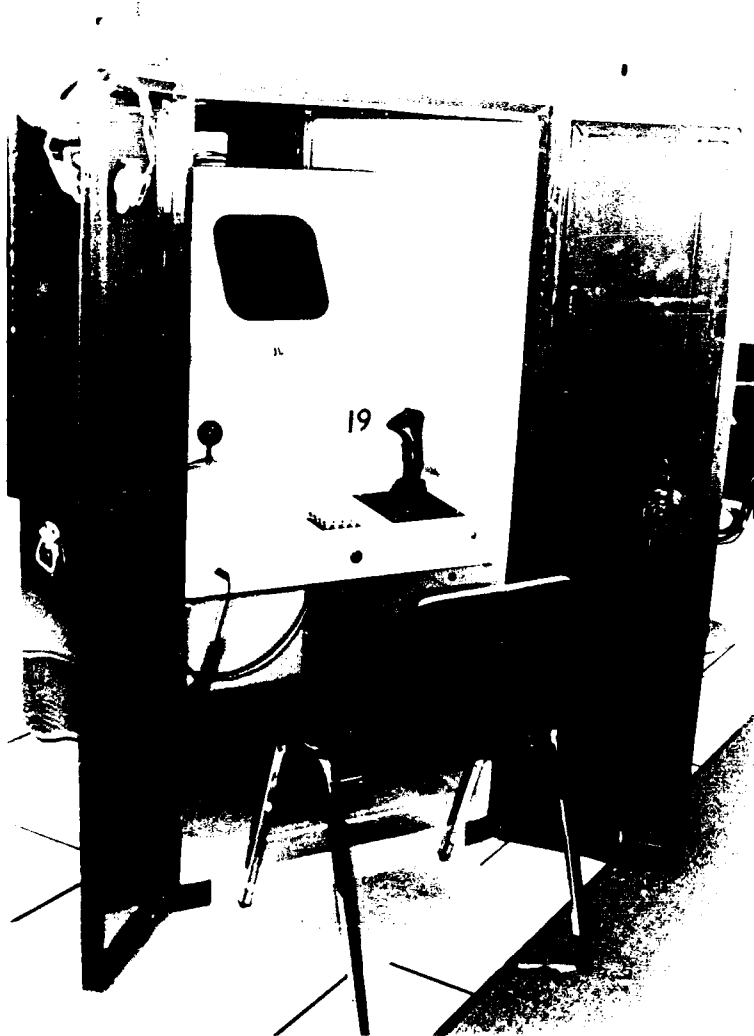
PORTA-BAT

Aircrew Selection Programs

The Air Training Command (ATC) field test of the Pilot Candidate Selection Method (PCSM) is progressing on schedule. The PCSM combines scores from the Air Force Officer Qualifying Test (AFOQT), grades from the last four sorties of the Flight Screening Program (FSP), biographical information, and scores from a psychomotor (hand-eye coordination) test into a final score that is highly predictive of success in pilot training. The psychomotor test is given by the PORTA-BAT test system.

The PORTA-BAT also gives a battery of information processing and personality tests referred to as the Basic Attributes Tests (BAT). The BAT and PORTA-BAT are being used by allied air forces in two major international R&D programs. The Royal Australian Air Force began a cooperative testing program with AFHRL in June 1986. Two PORTA-BAT systems were sent to Australia and are being used to test pilot applicants, helicopter pilots from the Australian Army and Navy, and combat crewmembers from operational squadrons. The goals of this program are: to independently validate the BAT as a screening/classification instrument for pilot selection and classification, to examine the utility of the BAT for selecting helicopter pilots and other aircrew positions, and to suggest possible tests or improvements from Australian R&D programs.

A second international R&D program is being conducted as part of AFHRL's support of the EURO-NATO Aircrew Selection Working Group. In this program, the PORTA-BAT is being used in Germany, Great Britain, Denmark, the Netherlands, Norway, Belgium, Italy, and Portugal, as part of an effort to improve the selection of fast-jet (fighter) pilots for entry into the EURO-NATO Joint Jet Pilot Training (ENJJPT) Program. This project is designed to select pilots who will succeed in becoming "fighter pilots" as opposed to the universally assignable pilot produced by the USAF Undergraduate Pilot Training (UPT) program. The aim

A basic trainee takes the Basic Attributes Tests on the PORTA-BAT.

PORTA-BATs are dispersed worldwide.

of the Working Group is to increase the success rate of ENJJPT candidates and establish a standard NATO pilot selection system. Each participating nation has had the use of PORTA-BAT to test applicants during some portion of 1986 and 1987. Data are being shared between the individual nations and AFHRL who is analyzing the aggregate performance of all entrants in a combined sample.

Installation of a fighter pilot performance measurement system in the Air Combat Maneuvering Instrumentation Range (ACMI) at Luke AFB is scheduled for completion in late 1988. Data gathered from "real-world" airborne performance on the range will help establish criteria for selection into the fighter training track within the Specialized Undergraduate Pilot Training (SUPT) program.

Analysis continues in the performance of USAF ENJJPT graduates against USAF UPT graduates in Lead-In Fighter Training (LIFT). The project is designed to investigate the effect of different training syllabi used by the UPT and ENJJPT programs on common performance in follow-on fighter training programs.

Two related projects using PORTA-BATs to improve aircrew selection are planned. One PORTA-BAT will be sent to Mather AFB for Undergraduate Navigator Training studies and another will go to Ft. Rucker for a joint R&D effort with the Army Research Institute on undergraduate helicopter training. Currently under consideration are proposals for joint testing programs with Israel and India.

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Training will focus on the _thinking_ required for modern Air Force work centers.

FORCE MANAGEMENT SYSTEMS BRANCH

The Force Management Systems Branch develops and monitors dynamic models used to describe the Air Force manpower and personnel system. It develops and applies new methodology or technology toward effective personnel subsystem design. It applies existing technology in the development of models for operational users to aid in their management decisions and in forecasting future needs to meet mission objectives, and conducts research into a wide range of Air Force personnel and manpower problems which occur during the military career life cycle (recruitment to retirement). It also conducts R&D to assess jobs to improve training and adjustability.

Basic Job Skills Research Program

Modern Air Force work centers reflect the advances that have established the Air Force as a "technological pacesetter" in today's world. That role carries with it the need to define the intellectual demands that complex systems levy on workers, so that training can be designed to keep pace with rapidly developing hardware technologies. In response to this need, a large-scale R&D effort--the Basic Job Skills (BJS) Research Program-- has been initiated. The overall goal is twofold: (a) to examine Air Force occupations in order to define high-tech competence in terms of the skills that are shared across domains, and (b) to develop adaptive training based on the

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skill commonalities. Basic job skills are defined as the core knowledge and thinking processes that underlie expert performance in the Air Force's most technically demanding tasks. They can be considered the components of scientific literacy needed for performance in today's high-tech work environments.

Precise definitions of shared skills can produce answers to questions about the optimal knowledge humans should have in work centers saturated by "smart machines." Training will be able to focus on the _thinking_ required for modern Air Force work centers, with the goal of fostering "performance with understanding." Payoffs will also be derived from centralizing the instruction for thousands of apprentices in a streamlined instructional system that takes advantage of Air Force Specialties (AFS) commonalities.

A three-stage R&D approach has been implemented to produce task analyses, diagnostic tests, and training outcomes. First, cognitive task analysis methods to capture the mental processes of technical expertise are developed and tested. In the second stage, problem-oriented tests are developed to diagnose trainees' deficits in the skill areas. In the third stage, results from cognitive analyses provide the basis for a series of problem-oriented training systems designed to cover more and more skills and occupations. The initial instructional systems will present trainees simulated troubleshooting environments using intelligent tutor computer systems. During FY87, three specific efforts tied together the three-stage R&D approach to produce effective training systems.

A successful proof-of-concept training R&D effort was accomplished in November 1986 with avionics maintenance technicians. The primary goal of the project was to test the BJS project's fundamental concept; namely, that the mental processes of technical expertise that are captured through cognitive task analyses can spawn an effective instructional program. In the effort, statistically significant improvements in the troubleshooting efficiency of novice airmen were obtained after five hours or less of tutoring on authentic troubleshooting scenarios.

The initial operational test and evaluation of the first major BJS training system was initiated in August 1987. The Avionics Troubleshooting Tutor provides approximately 50 hours of instruction for F-15 integrated avionics technicians in an intelligent tutoring system practice environment. The effectiveness of the tutor is being evaluated in a controlled experiment at three F-15 TAC bases. The evaluation project goals are to determine how much experience (in terms of months on the job) the tutor provides and how the accelerated rate of acquiring technical experience impacts shop-level productivity.

Prototype development of computer-based BJS instruction was completed for an important technical skill in electronic domains--facility with digital circuitry _logic gates_. The instruction utilizes intensive cognitive diagnostic methods derived from cognitive task analyses results. An individual trainee's particular knowledge deficits and procedural weaknesses are diagnosed, and then a tailored training regimen is delivered via computer.

A new approach to personnel assessment and training will be investigated in FY88. Based on cognitive task analysis of Air Force Specialty Codes (AFSCs), improved diagnostic tests to identify basic skill deficiencies will be developed. This work will be followed up by a 6.3 basic skills project which will be training- as well as testing-oriented. A prototype basic skills training program will be developed and validated against measures of job effectiveness. Diagnostic tests and training programs will be developed for additional AFSCs during FY88 to FY92. A complete basic skills testing and training program will be transitioned to the Air Force for operational use in FY92.

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Productivity Measurement/Enhancement

Air Force organizations are under tremendous pressures to reduce the cost of operation while at the same time maintaining or even increasing their productivity. The President's recent Executive Order to increase productivity by 20 percent by 1992, and the Gramm/Rudman/Hollings Budget Reduction Act, have placed an additional strain on military organizations. Existing methods of measuring productivity are too simplistic and have little motivational value for workers. What is needed is a tool which not only measures unit productivity but also provides avenues for increasing unit performance and improving worker motivation.

AFHRL R&D on feedback, goal setting, and incentive systems and productivity measurement has culminated in a series of technologies, collectively called the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM), which permit the development, in any organization, of a complete productivity measurement and enhancement system. Developing an MGEEM system requires a measurement coordinator who guides members of the target organization through a multistep process to clarify what the organization is expected to produce, called Key Results Areas (KRAs), and to identify means of evaluating how well the organization is accomplishing its KRAs, called indicators. Reports for feedback to management and workers are accomplished with the target organization's existing data automation system.

With comparatively low start-up and operational costs, the MGEEM can incorporate part or all of an organization's

PERFORMANCE INCREASE

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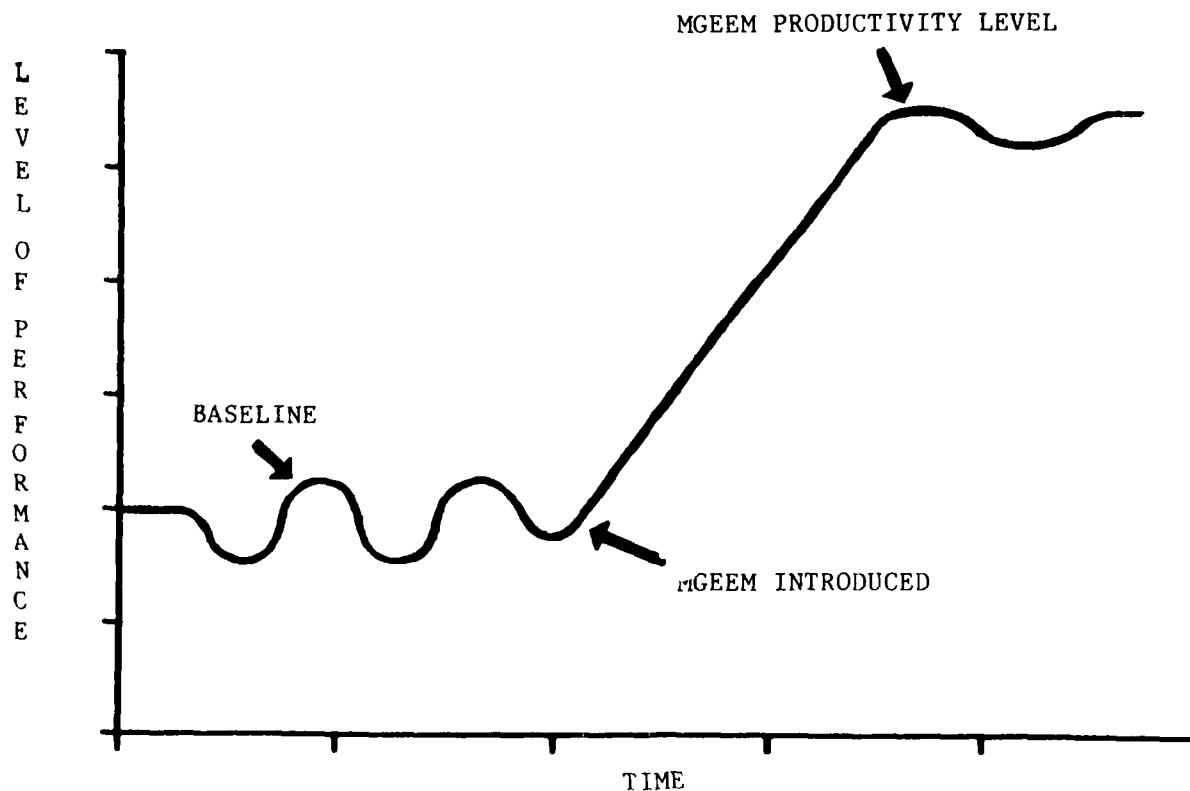
existing accounting and engineering systems, but goes beyond these measures, to directly assess all important aspects of the mission. The MGEEM is highly motivational because its design considers worker input, yet it preserves the prerogatives of traditional military management. Extensive field tests of the MGEEM show that it dramatically increases organizational productivity from 67 to 93 percent, and is motivational because of its use of feedback, goal setting, and incentives. Commanders report that the MGEEM focuses on the truly important aspects of the organization's mission. In addition, MGEEM increases management's control by identifying problems before they become serious, diagnosing causes for problems, knowing when problems are fixed, identifying priorities for increasing productivity and better allocating resources.

There has been widespread interest and activity in MGEEM during FY87. In April 1987, a Productivity Workshop was held at Brooks AFB with over 30 representatives of major commands attending. This workshop provided a tutorial on how to implement the MGEEM in their organizations. Several implementations are in progress or planned in the Air Force, including the Plans and Programs organization and Procurement Directorate of Air Force Logistics Command, Air Force Management Engineering Agency, Electronic Security Command, Air Force Office of Security Police, Pacific Air Forces, and Tactical Air Command. In the Navy, the Aircraft Intermediate Maintenance Department at North Island Air Station of Navy Air Forces Pacific implemented MGEEM in June 1987, while the Naval Weapons Evaluation Facility is planning to implement it. AFHRL has also submitted a proposal to the Office of Assistant Secretary of Defense for a tri-Service test and evaluation of MGEEM in aircraft maintenance organizations. In addition, both the Office of Management and Budget, and the Department of Defense, are considering the usefulness of MGEEM in satisfying the President's Productivity Program goals.

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PRODUCTIVITY MEASUREMENT SYSTEM
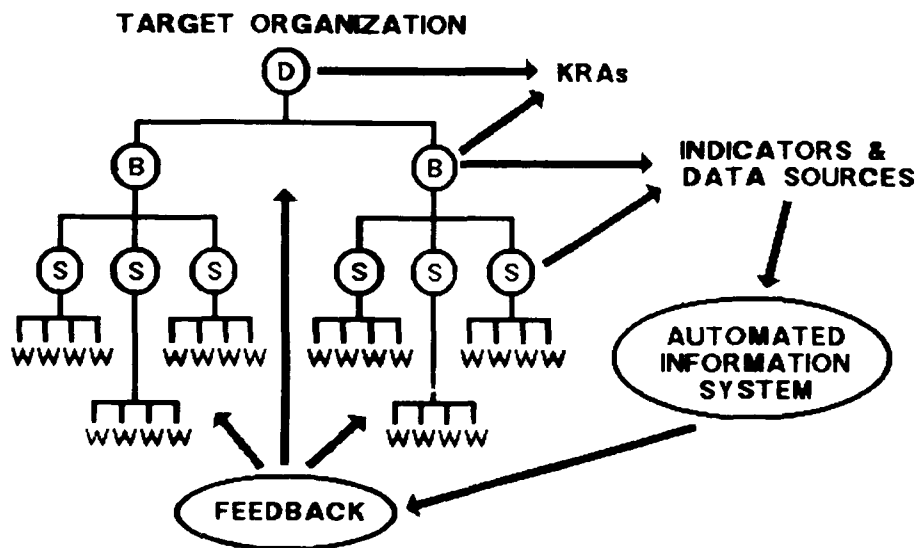
VALUE OF AIR FORCE EXPERIENCE
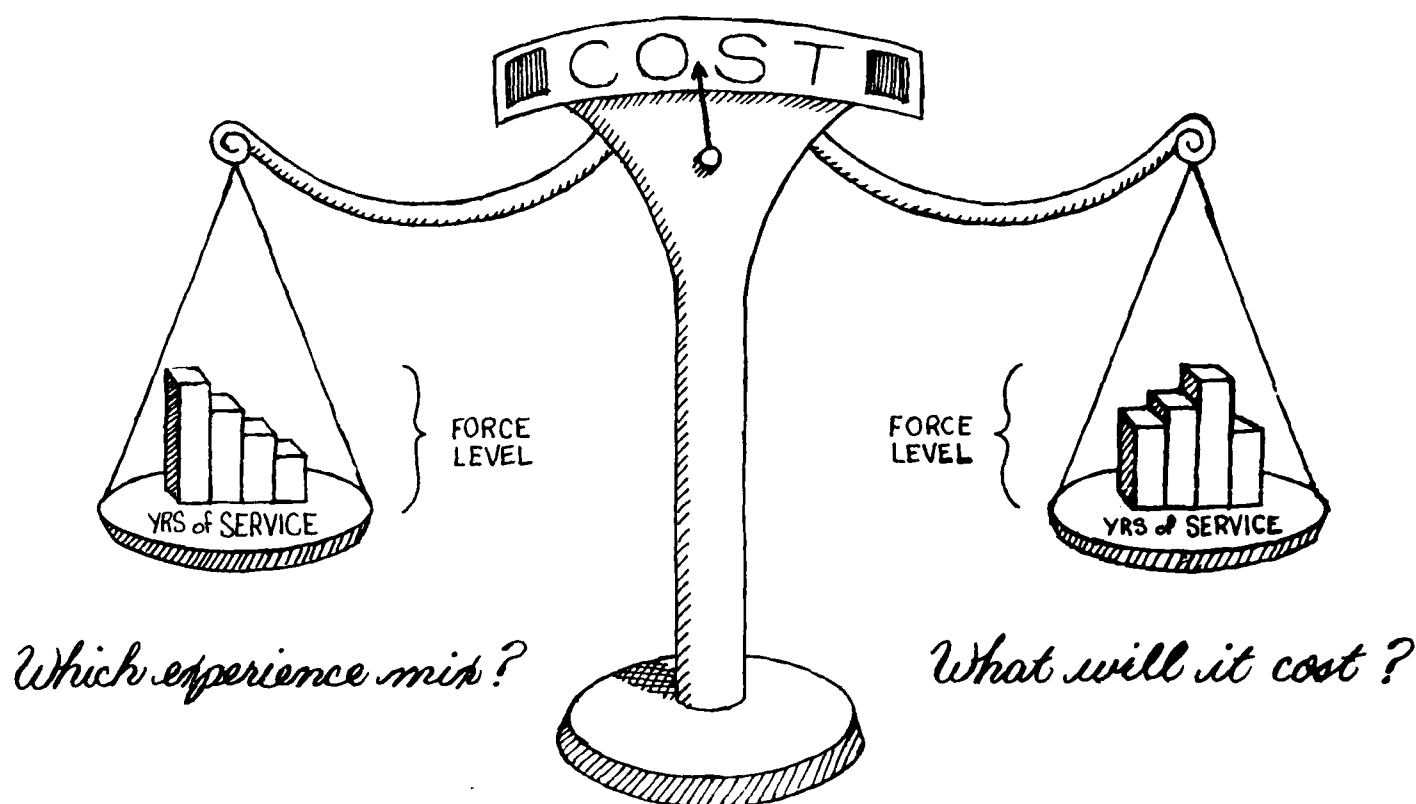
Value of Air Force Experience

In reacting to budgetary constraints and cost-saving measures and initiatives, the Air Force is constantly faced with making decisions about the nature of the enlisted and officer force structure mixes. Unfortunately, many of these decisions are made with very little information about the impact that cost-cutting might have on mission accomplishment. Also, not considered is the impact that cost savings taken today might have on the future ability of the Air Force to recruit and retain the kinds of people necessary to operate and maintain the complex weapon systems that will be in the inventory. The key to answering such questions is a defensible and scientifically founded methodology to quantify the value of experience gained in the Air Force in critical occupations and duty assignments. Such a methodology would enable Air Force manpower, personnel, and training planners to respond to Congressional and DOD inquiries about the impact of losing trained personnel and empower them to make better-informed force structure tradeoff decisions.

The R&D effort to develop such a methodology is being accomplished in three phases. The objective of Phase I is to define the unique characteristics of the Air Force job environment, training, and occupational experience that may suggest one or more of the currently accepted human value models (e.g., human resource accounting or human capital modeling). The R&D may also explore policy and decision modeling of key value variables. Necessary assumptions, and reasons why one or more of the models is preferable to another for use in the Air Force and military setting, are being examined.

In Phase II, one or more of the current human value models, modifications of the models, or new approaches will be selected for testing in the Air Force setting.

Models will be developed for several key Air Force occupations, occupational groupings, and experience year groups. In Phase III, the sensitivity of the models to changes in assumptions, costs, time horizons, and other key decision variables will be evaluated. Concrete suggestions will be made as to the feasibility of extending the models to the larger Air Force occupational arena.

The R&D being conducted will result in a policy analysis tool which will improve Air Force understanding of the cost and value of replacing personnel who possess critical Air Force skills. Such a model will improve the Air Force's budgeting and manpower, personnel, and training decision-making processes. Better informed force structure and retention policies should also result from this knowledge.

Following an extensive review of the pertinent literature in human resource accounting (HRA) and human capital modeling, a request for proposal was issued under the Program Research Development Announcement (PRDA) procurement program, and two firms were awarded contracts in April 1987. One of the firms, RRC Inc. of Bryan TX, is employing Dr. Eric Flamholtz's HRA model and has him, the nation's leading expert on the application of HRA, under consulting subcontract. RRC is focusing on key cost variables and how they could be used to value experience. The other firm, Advanced Technology of Reston VA, is evaluating a wide range of possible ways to measure the current worth of an Air Force individual in a job and will ultimately produce a software package which will incorporate both firms' value models. Both firms' models will be tested on critical enlisted and officer occupations for which personnel may be difficult to replace or retain and/or costly to train.

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Expansion of Person-Job Match (PJM) Technology

With reduced budgets and an increasing emphasis on cost reduction, the Air Force must utilize its limited resources to train personnel and maintain a force with sufficient talent and ability to accomplish its mission. Key to making optimal use of important personnel resources is making the best possible decisions about selecting, classifying, and assigning personnel. Existing systems for making these decisions can be improved resulting
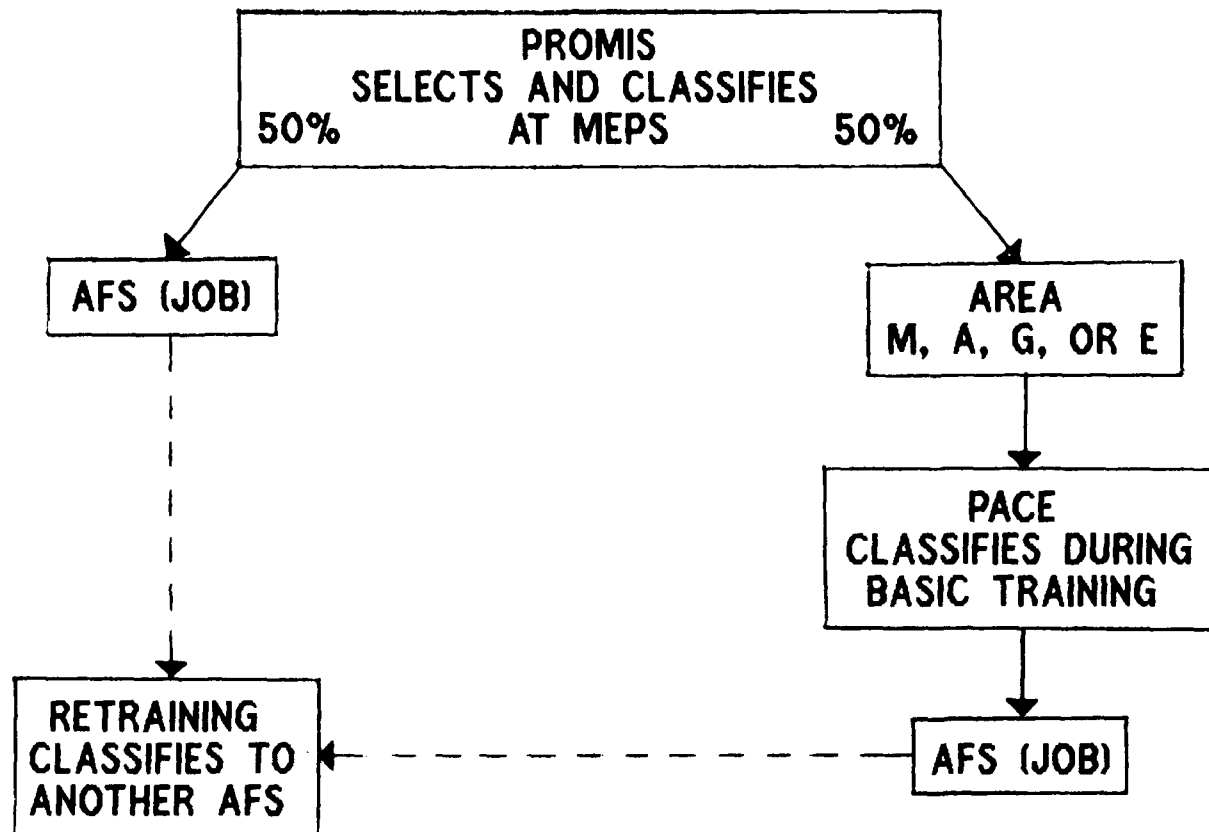

Person-job matching begins with recruitment.

in a more effective selection and classification process. This improvement is being accomplished through the expansion of Person-Job Match (PJM) technology.

There are three enlisted selection and classification systems used by managers at Air Training Command (ATC), Air Force Military Personnel Center (AFMPC), and Recruiting

PJM
CLASSIFICATION SYSTEMS

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                    ┌─────────────────────────────────┐
                    │            PROMIS               │
                    │   SELECTS AND CLASSIFIES        │
                    │  50%        AT MEPS      50%     │
                    └─────────────────────────────────┘
              ┌───────────────────┐         ┌──────────────────┐
              │   AFS (JOB)       │         │      AREA        │
              └───────────────────┘         │   M, A, G, OR E  │
                       ┊                     └──────────────────┘
                       ┊                              │
                       ┊                     ┌──────────────────┐
                       ┊                     │      PACE        │
                       ┊                     │ CLASSIFIES DURING│
                       ┊                     │  BASIC TRAINING  │
                       ┊                     └──────────────────┘
              ┌───────────────────┐                   │
              │   RETRAINING      │         ┌──────────────────┐
              │  CLASSIFIES TO  ◄─┼─ ─ ─ ─ ─┤    AFS (JOB)     │
              │  ANOTHER AFS      │         └──────────────────┘
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Service. The Procurement Management Information System (PROMIS) selects and classifies nonprior-service enlisted personnel into specific Air Force Specialties (AFSs) or into an Air Force aptitude area (Mechanical (M), Administrative (A), General (G), or Electronics (E)). Personnel classified into an area are called aptitude index (AI) enlistments. The Processing and Classification of Enlistees (PACE) system classifies the AI personnel into specific AFSs during basic training. In the retraining area, over 10,000 airmen are selected each year for retraining into new specialties. The R&D efforts in support of PROMIS, PACE, and retraining will improve the selection and classification of airmen.

The PROMIS classification algorithm assigns personnel at time of enlistment based on the worth or payoff of that person in an AFS combined with the prediction of future accessions for the AFS. During FY87, the R&D efforts to enhance PROMIS included new methods to predict future accessions and consideration of alternate sequential classification algorithms. Research is continuing on several issues such as adding new information for use in evaluating the worth of a person on a job, including the Vocational Interest-Career Examination, and implementing improved regression equations to predict technical school success.

Research in progress will upgrade PACE to take advantage of past PJM R&D and use state-of-the-art linear programming techniques. During FY87, a new PACE prototype algorithm was developed through extensive discussions with managers at ATC and the 3507 Airman Classification Squadron at Lackland AFB. Initial testing using actual training week group data was started. In addition, R&D is continuing to test and evaluate the prototype by running both the existing and new PACE classification systems in parallel, and to develop an upgraded version of the new PACE program.

The primary objective of the retraining classification R&D is to develop a methodology that will optimally classify enlisted personnel selected for retraining. The current system is a nonoptimal paper-and-pencil matching process. The new retraining system will utilize PJM selection and classification methodology already developed in the PROMIS and PACE systems. During FY87, a classification algorithm for nonvolunteer personnel was developed in close cooperation with AFMPC retraining managers and is now undergoing operational testing. Research to develop a system for retraining volunteers is now getting started.

The R&D effort will result in three systems which will classify personnel in a similar and optimal manner. A project to assess and quantify the benefits to be derived from this R&D was recently begun. Several areas being examined include increased retention, less attrition, less casual time, improved matching of abilities with the difficulty of the AFS, and increased job satisfaction and motivation by better consideration of personal interests.
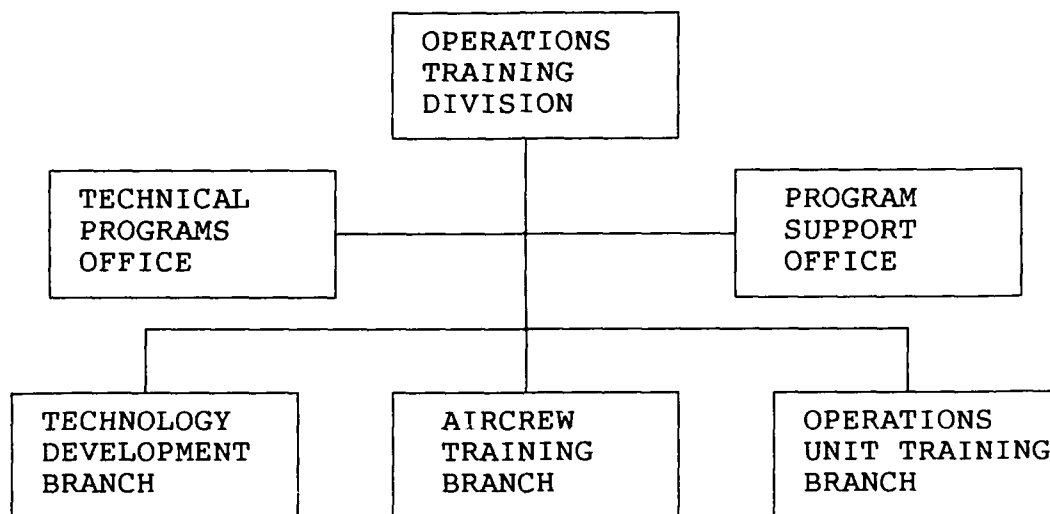
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The Operations Training Division (OT) of AFHRL has a unique role as the only Air Force agency devoted to the exploitation of science and technology to improve aircrew training. The Division's R&D programs dynamically contribute to the effectiveness and efficiency of flying training throughout the Air Force.

Formed in 1969 as that integral part of AFHRL responsible for flying training, OT performs its mission through two primary functions: (a) behavioral R&D to solve flying training problems through improved technology, and (b) engineering R&D to develop devices that become vehicles for R&D and training. The people who staff these two areas form a diverse multidisciplinary team of specialists ranging from psychologists, R&D instructor pilots, and human factors specialists to aerospace engineers, mathematicians, and computer technologists. With this uncommon mix of expertise, the Division converts training needs into the knowledge and products needed to improve the combat effectiveness of operational commands.

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TECHNOLOGY DEVELOPMENT BRANCH

The Technology Development Branch plans, programs, develops, and evaluates prototype aircrew training devices to serve as research vehicles and technology demonstrators. Products of this Branch are primarily aircraft simulator components and part-task trainers, including host computational systems, image (visual, radar, and infrared) operators, image display devices, and technical evaluations thereof.

Aircrew Combat Mission Enhancement

Aircrew Combat Mission Enhancement (ACME) is a Forecast II project whose goal is the enhancement of combat mission readiness through advances in flight simulation technology. There are two principal products that will be developed and delivered under ACME. These are: (a) a situational awareness training capability that will permit multiship force-on-force combat simulation, and (b) a mission
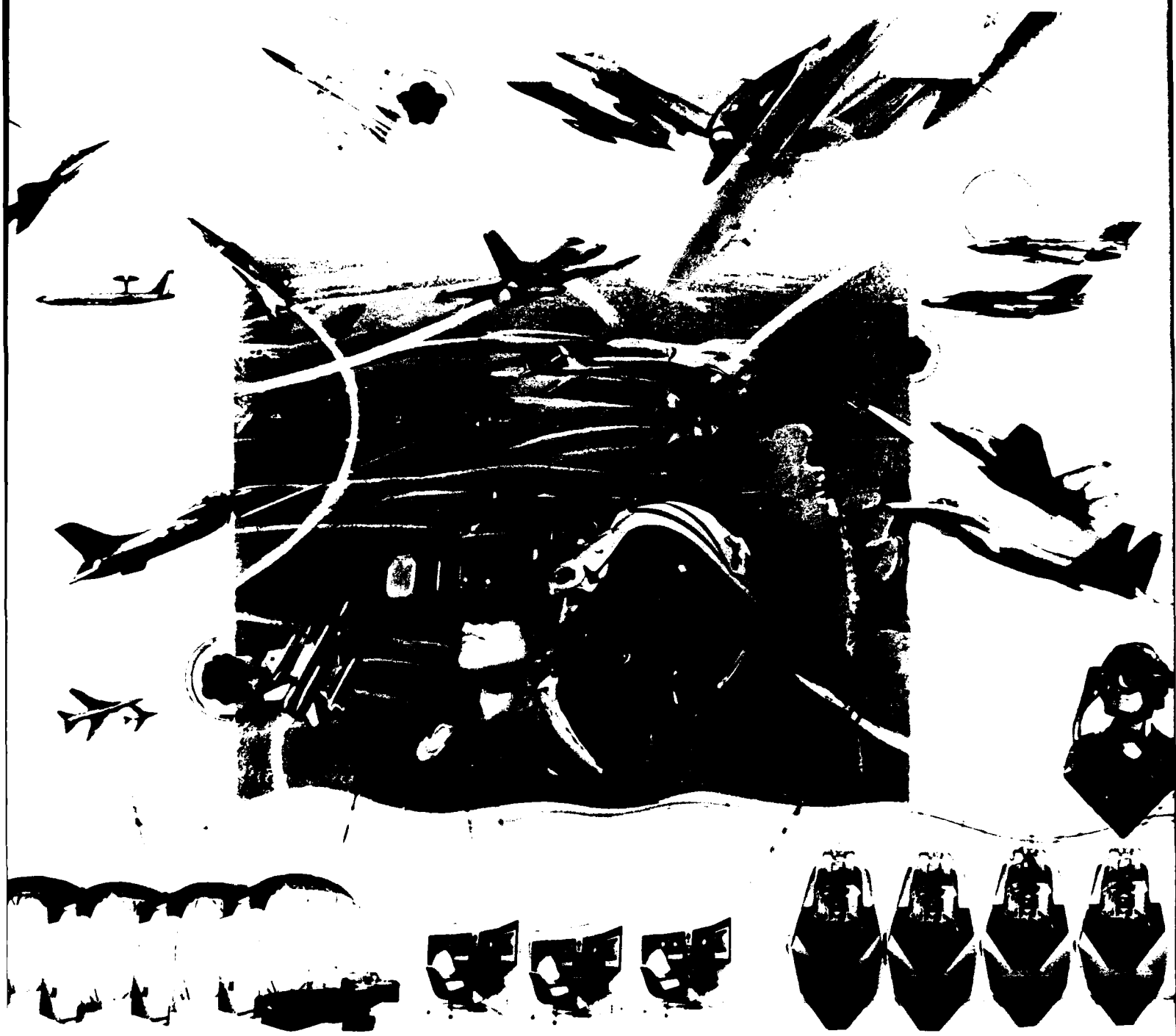
The near-term objective of the Aircrew Combat Mission Enhancement (ACME) project is to provide advanced, cost-effective simulator technology for combat situational awareness and team training, mission rehearsal, and mission planning systems for tactical aircrews.

rehearsal training capability that will permit terrain/target familiarization and practice of attack coordination and timing.

The need for ACME is based on prevailing operational problems, including the inherent limitations in the use of current tactical ranges and the fact that frequency of practice is severely limited. Furthermore, there are presently no capabilities within the Tactical Air Forces (TAF) which permit mission rehearsal. In order to address these operational limitations, there are pushes in current technology which are necessary, including affordable simulation components, long-haul networking for interactive force-on-force exercises, and rapid turnaround data bases for mission

rehearsal. There is also a need to expand our knowledge in the areas of understanding the skills required for situational awareness and mission rehearsal, fidelity requirements for trainer components, effectiveness of ACME products, and understanding of how these products would be integrated within the total training system.

ACME is a Forecast II technology for which AFHRL is the lead organization. Forecast II resulted in an AFSC-wide program to develop 39 technologies and 31 advanced systems concepts that, hopefully, will revolutionize the way the Air Force carries out its mission in the 21st century, guaranteeing continued technological supremacy over any potential adversary. The objective of ACME is to

provide cost-effective simulator technology for combat mission training, mission rehearsal, and mission planning for tactical aircrews. This technology would be provided by: expediting the development of high-resolution, multispectral, geographic gaming areas; expediting the development of very-high-speed integrated circuit (VHSIC) computer-based systems that allow increased simulation capability while significantly reducing size and cost; developing the helmet-mounted display and multiparticipant networking technologies required to support simulation of tactical combat tasks; and integrating diverse technologies to define combat mission training, mission rehearsal, and mission planning systems for high-threat environments. Other organizations working with AFHRL in the conduct of ACME are: the Air Force Wright Aeronautical Laboratories (AFWAL), the Rome Air Development Center (RADC), the Armstrong Aerospace Medical Research Laboratory (AAMRL), and the Aeronautical Systems Division (ASD).

Important milestones are: demonstrate integrated visual, infrared, and synthetic radar capability in the Advanced Visual Technology System (AFHRL/6.3/FY88); demonstrate ACME brassboard of airborne graphics generation system (AFWAL/6.2/FY88); demonstrate automatic vertical feature extraction (RADC/6.3/FY90); tactical networking concept definition (AFHRL/6.2/FY90); demonstrate brassboard miniature real-time computational system (AFWAL/6.3/ FY91); demonstrate multi-source imagery merger and display (RADC/6.3/FY93); and delivery of a computer image generation unifying device (AFHRL/6.3/FY96).

The near-term Situational Awareness Training (SAT) system development program will produce an interactive force-on-force simulation of a wartime environment. To accomplish this, an F-16 multiship network will be developed at Williams AFB. The network will consist

of high-fidelity simulators, low-fidelity pilot stations, generic operator control stations, a mission control station, and a modular threat simulation system. The network will enable up to 14 live players to participate in tactical scenarios. This complex will have the capability for long-haul networking to other simulation facilities. Candidate facilities include the Simulator for Air-to-Air Combat located at Luke AFB, the Visual Training Research Simulator facility of the Naval Training Systems Center located at Orlando, the SIMNET complex located at Ft. Knox, a new R&D simulation complex being built at Ft. Rucker, and the proposed Fighter Battle Management Facility at Wright-Patterson AFB. This network will be expanded for inclusion of selected command and control capabilities. The situational awareness training capability will be delivered by FY92.
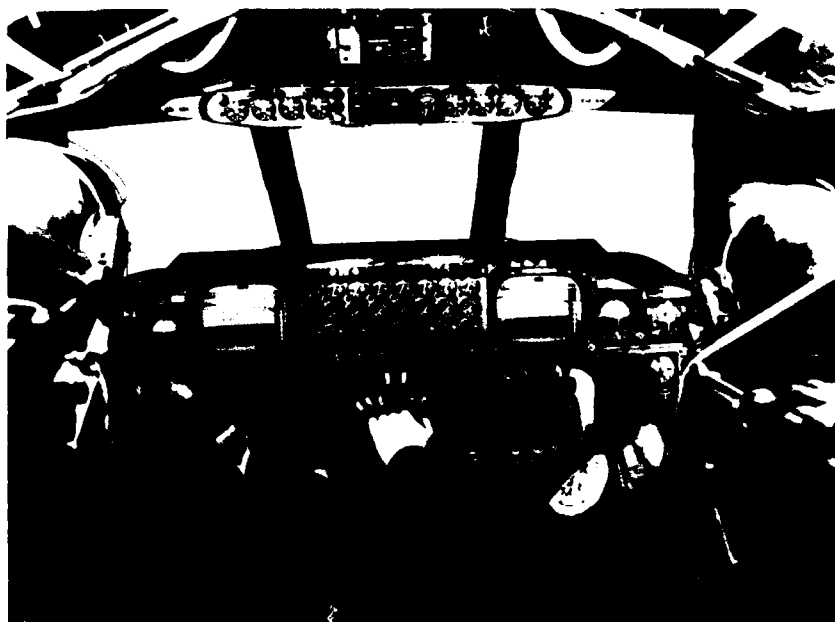

The Mission Rehearsal (MR) system development program will produce a system capable of prestrike mission planning and rehearsal. It will enable crews to practice waypoint/target area familiarization and attack coordination and timing. Technology requirements include the development of a multispectral image generator and a quick turnaround database facility. These will be integrated with the situational awareness training facility and be available by FY96.

A vigorous program of behavioral R&D will be undertaken in support of these two development programs. For each, there is a need for identification of training requirements and an assessment of the underlying aircrew skills. For the situational awareness program, fidelity requirements for the various trainer components will be identified as well as feedback requirements for effective training and practice. For mission rehearsal, the primary behavioral issue is the one of data base requirements. Upon completion of these development efforts, their effectiveness will be evaluated, and integration into the total training system will be addressed.

Although ACME is a new program, significant progress has been made. Component development efforts are underway in the areas of visual image generation and display systems. A multi-spectral image generation capability within the Advanced Visual Technology System is nearing completion. A second-generation fiber-optic helmet-mounted display has been delivered and is currently being evaluated. Development efforts are also underway for two dome display systems employing variable acuity optics. Other components of the situational awareness training system are currently in the design stage including the required networking communication standard, the mission control stations, the modular threat simulation system, and a series of low-cost combat stations that will permit increases in the number of players within the simulation scenarios. It is expected that development of these systems will begin during FY88.

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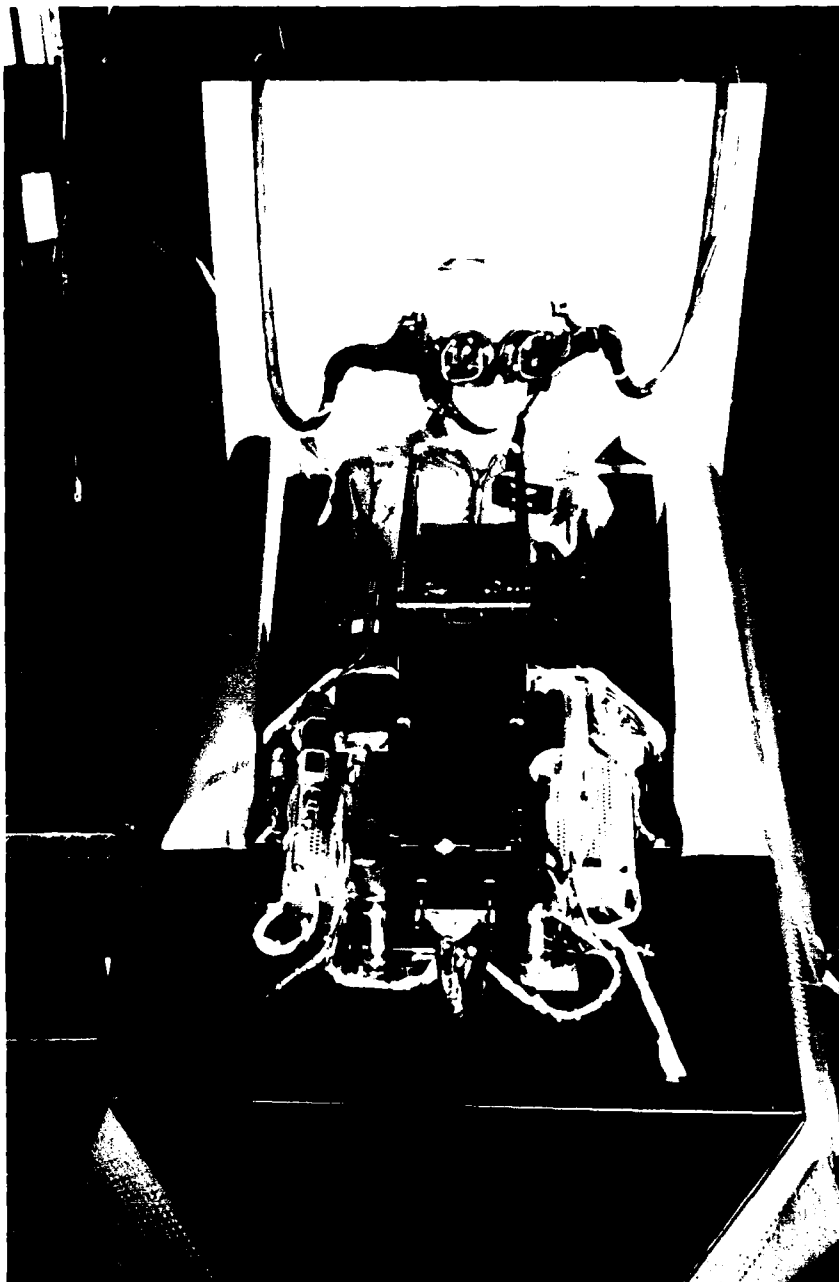
This full-color, collimated, stereoscopic display is exceptionally bright, thus allowing the pilot to make full use of high-detail scenes.

Visual Training Effectiveness R&D

R&D in this area is concerned with determining the training benefits associated with various aspects of the visual display and associated imagery for out-of-the-cockpit flight simulation. The three components that drive the cost of today's systems are the image generator (IG), the data base, and the display itself. The primary objective is to relate the level of fidelity to training effectiveness. The major customer for this work is the Training Systems Special Project Office of the Aeronautical Systems Division. Particular questions of interest to them include: How valuable is the training provided by visual systems? How much fidelity is required to support specific training objectives? How should the visual requirements be specified in terms of engineering parameters? Research in this area also includes topics tied to programs in the Division's advanced technology development area and to visual-related issues of interest to the Army and Navy. This portion of the visual training effectiveness R&D is coordinated through the Visual Training Effectiveness Working Group.

Research is currently ongoing in four areas: (1) target display requirements, (2) scene content, (3) field of view, and (4) the use of color. Ultimately, training effectiveness deals with transfer of training from the simulator to the aircraft. Due to the cost, time, and technical difficulties involved in conducting transfer-of-training experiments for each level of all the factors involved, an R&D strategy has been adopted which first searches to find significant performance differences within a controlled experimental situation. And then other measures of effectiveness are used including within-simulator performance and psychophysical perceptual judgments. When appropriate, these differences are verified using a transfer test.

In order to support this R&D program, a wide variety of equipment is required. At present, two image generators are being used as well as a graphics system. Displays include the A-10 dodecahedron with color CRTs, the fiber-optic helmet-mounted display system, and the Visual System Component Development Program limited-field-of-view dome, two smaller 5' diameter domes, rear-projection screens of varying gains, and several types of color light valve projectors.

Two other R&D efforts have been started during FY87 that may have significant impact on future design requirements. One project involves studying the effects of display parameters such as update rate, interlacing, brightness, and contrast on the perception of form and motion of a moving target. This area of R&D is critical to the development of satisfactory air-to-air combat training displays. Results obtained to date show that interlacing and update rate both impact the perception of form and apparent motion. The magnitude of these effects and the training impact on realistic tasks have not yet been established.

Another major effort initiated during the last year concerns the use of color in out-of-the-cockpit scenes. Almost all visual systems use color. However, the colors never appear realistic. The Division has undertaken a program which addresses the cause of this problem and will provide recommendations for solutions. A multiphased approach has been taken initially. The goal is to define objectively the engineering characteristics of the color displays, and to determine how to control the color output and how to derive a scheme for assuring that the color output matches the intended color. Ultimately, the R&D will investigate the optimal use of color for render-
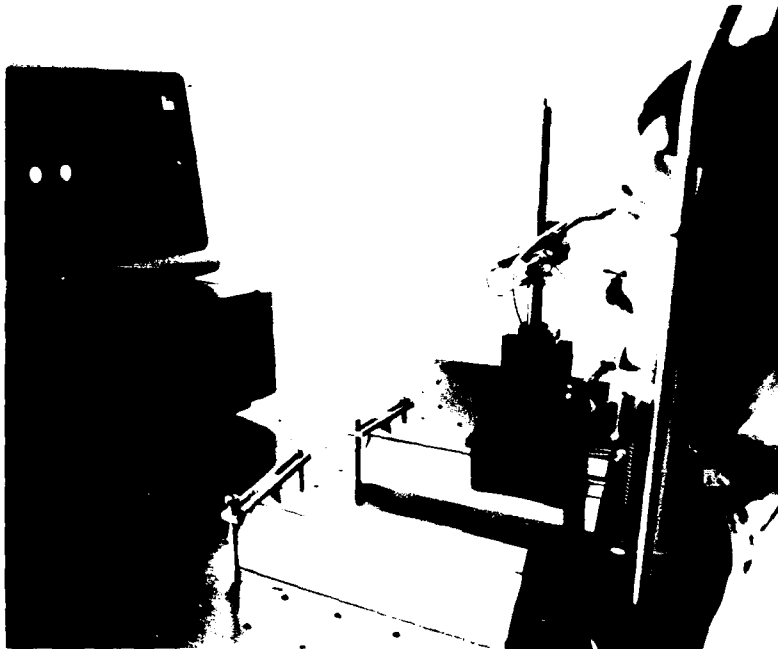
Basic research is exploring how information is selected by the human visual system for processing.

ing realistic scenes. Because the appearance of color changes as a function of the brightness levels, the Branch has conducted an extensive analysis of the brightness levels in light valve projection and large CRT displays and found them to be in about the bright moonlight night range.

Quite different explanations for many of the problems observed focus on the relatively low level of brightness and substantial day-to-day variation in the displays, combined with the fact that the functions relating intended color to obtained color differ between CRTs and light valves.

Since most color science is based upon higher brightness levels than those used in flight simulators, work has been started to objectively define how the colors will appear in typical scenes. A comparison of the color production of two types of color light valve projectors, one representing state-of-the-art technology, has also been conducted. The

new technology seems to offer better production and control of certain colors, but the value in terms of training benefits has not yet been determined.

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AIRCREW TRAINING BRANCH

The Aircrew Training Branch (OTA) is primarily responsible for managing, updating, maintaining, and operating the major simulation facilities located at Williams AFB, Arizona. These facilities provide the foundation for R&D on training effectiveness and flight simulator engineering. The simulation systems include dome, dodecahedron, and helmet-mounted visual displays; computer image generation systems; and related R&D equipment. They are capable of simulating F-16A, F-16C, and A-10 aircraft. These simulation systems support R&D conducted under Project 1123, Flying Training Development, and Project 6114, Flight Simulation Technology, as well as R&D conducted under Program Element 63227F, Advanced Simulator Technology; and thus provide the primary simulation capability for implementing, demonstrating, and testing training technology and simulation hardware advancements.

The major projects supported by the Branch are 1123, 2363, 2743, and 6114. However, there are several other noteworthy Branch activities. These activities center around the implementation of new technologies to enhance simulation performance.

One of the Division's primary R&D systems is the F-16A R&D simulator. This system simulates a high-performance F-16A block 15S aircraft using a limited-field-of-view head- and eye-tracking dome display system and the Advanced Visual Technology

AVTS accesses sixteen cell texture maps, creating
a realistic nap-of-the-earth flight simulator.

System (AVTS) computer image generator. To provide for more realistic simulation, several enhancements are being made to this technology demonstrator simulator. Upgrades include new computational equipment, 60 Hz aerodynamics, a new advanced Instructor Operator Station (IOS), and a highly advanced universal I/O linkage system. This universal Input/Output (I/O) linkage system is part of a distributed microprocessor architecture (called MST-2M) that can be upgraded to full flight simulation computation capability if desired. Upgrading the F-16A will be the first step toward an operational distributed microprocessor system that will take advantage of the new generation of high-speed microprocessors and high-speed I/O from memory to cockpit (lowering transport delay). The new IOS will incorporate the latest advancements that the Division has made in IOS technology and design issues. Integrated with the IOS will be a Second Viewpoint Control Station (SVCS) and the Air Combat Performance Measurement System (ACPMS). The SVCS will provide dual-ship capability. The ACPMS will be able to run training missions and collect data for R&D projects.

Another major enhancement being implemented into the Division's simulation systems is an enhancement of the AVTS. The addition of cell texturing to the AVTS provides a capability for higher-density scene content for use in low-altitude training. Synthetic Aperture Radar (SAR) and Forward Looking Infrared (FLIR) channels are being added. The SAR and FLIR will be correlated with the visual scene. The update speed of the AVTS will be doubled and a second viewpoint added.

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OPERATIONAL UNIT TRAINING BRANCH

The Operational Unit Training Branch (OTU) is responsible for R&D programs directed toward solving operational problems in Air Force aircrew training at the individual, crew, and team levels. Branch projects address all facets of aircrew training which concern acquisition, maintenance, and reacquisition of flying knowledge and skills for such units. This Branch's primary objectives are to increase force effectiveness and survivability through enhanced combat readiness and flying safety. These goals are accomplished through R&D focused upon electronic combat training systems, development and implementation of aircrew performance measurement, simulator instructional strategies and technologies, total training system design, training system/device evaluations, and the development of part-task trainers capable of supporting unit training needs. OTU's products are data bases, procedures, and training devices validated through experimentation, field studies, and demonstrations. The Branch's activities promote the use of new training methods and efficient simulation utilization.

The Tactical Air Forces must always train for a situation that they hope never to face--combat. Development and maintenance of the critical war-fighting skills involve a complex training system in which academic instruction and ground-based simulation must be interwoven with in-flight training to accomplish specific
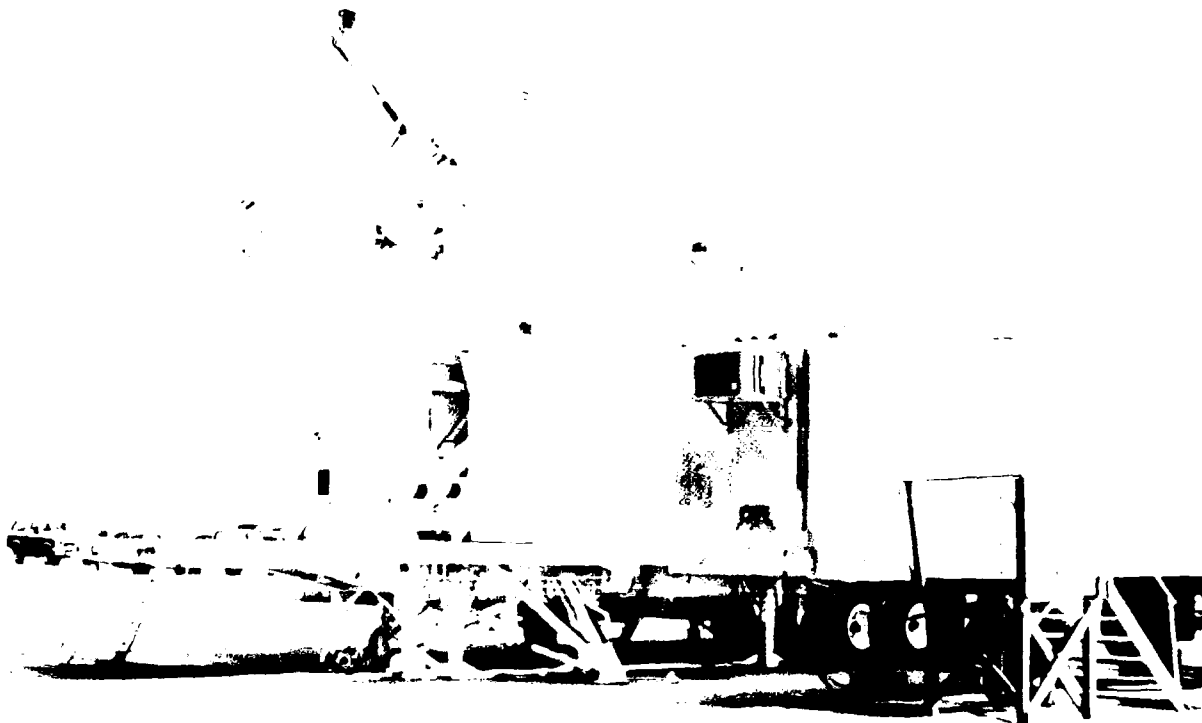
The electronic combat training effectiveness project will determine the optimal mixture of media for effective EC training.

training objectives. Because of the difficulty of accomplishing many of these training objectives, AFHRL/OTU is actively conducting training R&D with the Tactical Air Forces. These efforts include identification of training needs, development and evaluation of training alternatives, and integration of cost-effective training as part of the total training system.

Another program within OTU involves R&D in the area of electronic combat (EC) training. EC training is difficult because of the complexity of the training to be provided, the unusual requirements for secure communications, and the rapid rate of technological change. Full mission simulators, on-board systems, and part-task trainers can all provide some of the training, but it is not clear how an overall system should be designed to effectively integrate the various components of aircrew electronic combat training. Modular components are needed, and OTU plans to develop a Modular Threat Training System (MOTTS) prior to FY89. MOTTS will then be used as input to a multithreat, multiship, electronic combat training system to be completed in FY91.

Objective measures of air combat performance for training evaluation and feedback do not exist. To meet this need, Branch personnel have developed a performance measurement system at Luke AFB, Arizona that collects data from the Simulator for Air-to-Air Combat (SAAC) and the Air Combat Maneuvering Instrumentation (ACMI) ranges. By measuring the same air-to-air performance in both facilities, it is possible to collect and compare the same objective performance data in the simulator and the real world. The system is designed to support research in the development and validation of alternative air-to-air performance measures, as well as new techniques for graphically displaying air combat engagements. Functional capabilities of the system include: real-time monitoring and scoring of air combat performance, real-time graphic display of mission progress, and the storage of parameters needed to support ongoing R&D. The

system also includes capabilities such as: post-mission graphic replay for debriefing, a data base management system, and a statistical package for analysis of R&D results.

During the period from FY88 to FY91, work will be conducted on multicockpit Instructor Operator Station (IOS) design guides and modular IOS software. The multicockpit IOS will be capable of interfacing with eventual prototype configurations on an in-house two- to four-cockpit simulator by FY91. The modular software (developed as part of a joint-Service program) will be a standard IOS software package applicable to simulation in general.

Three aircrew performance measurement efforts will be conducted from FY88 to FY91. The first effort will develop and validate plans for a stand-alone Performance Measurement System (PMS) which is capable of acquiring data from the Simulator for Air-to-Air Combat (SAAC) as well as Air Combat Maneuvering Instrumentation (ACMI) ranges. This common-data base capability will be very useful for R&D purposes as well as for training progression purposes.

A second effort will identify and quantify relevant pilot behaviors required to defeat threats and to accomplish mission objectives in surface attack maneuvers.

A third will develop and evaluate a prototype Air Combat Assessment and Debriefing System (ACADS) for use with the F-16 aircraft. Specific components of this system will include: (a) a flight data recording system that can monitor and record the necessary parameters on-board the aircraft, and (b) a ground-based processing system that can process and present airborne data in a format suitable for performance analysis and replay after the aircraft has landed. ACADS will be functionally similar to an aircraft-mounted ACMI range system and will have the capability to be deployed to wing and squadron locations and used for local area training.

A critical component of ground based aircrew simulators is the instructor/operator station (IOS). The IOS is the medium through which users control the instructional support features that provide aircrews special training not available in the aircraft. This Branch is responsible for the development of guidelines and human factors data bases for IOS design. A generic IOS design concept which incorporates modular and transportable software is actively being developed and evaluated. Also, OTU is conducting R&D efforts on optimizing the design of the man/machine IOS interface. Such products have many uses in the development and acquisition of simulator IOSs and instructional support capabilities. At present, the primary users are the Aeronautical Systems Division, the Major Commands, and DOD contractors.

At the Division's Tucson operating location, the Tactical Training Evaluation Center (TTEC), established in 1985, is collocated with the 162d Tactical Fighter Wing of the Arizona Air National Guard. This working relationship has provided the opportunity to participate first-hand in Low-Altitude Training (LAT) R&D. This is the only LAT program currently authorized for the Tactical Air Forces, and it has already resulted in the development of a unique LAT flight course and training manuals. Development of a part-task trainer for visual cues has been completed and is used to enhance training on low-altitude flight. In the near future, the TTEC will serve as an operational training R&D laboratory for a number of projects, such as an in-house effort on visual cueing and transfer-of- training studies on air-to-air radar intercept tasks. Long-range plans include in-depth analysis of aircrew performance, combat readiness, and workload.

Another important role played by many of the people on the OTU staff is that of consultant, or subject-matter expert. Serving in this capacity, OTU personnel have given Air Force agencies valuable assistance concerning electronic combat

training, aircrew training device evaluation, computer-based instruction and management, and use of training resources. Although these interactions account for only a small portion of total duty time, they have significant impacts that directly result in changing the way the Air Force conducts its aircrew training.

Part-Task Training R&D

Today's aircrews must be highly proficient in many operational skills. The complex tasks confronting pilots and aircrew members have been characterized as comprising procedural, perceptual-motor, and decisional performance elements. The growing complexity of combat missions and the sophistication of aircraft contribute to an increasing demand upon the training process to ensure the proficiency of aircrews.

Aircraft avionics systems are designed to increase survivability. Included are systems such as radar warning receivers, chaff/flare dispensers, and electronic counter-measures pods. These systems permit aircrews to identify and monitor potential threats and to use tactics to defeat them. Survivability in combat is essential, but aircrews have few opportunities to engage in realistic training using these systems. In response to this deficiency, AFHRL/OT developed and validated an Electronic Combat Part-Task Trainer (ECPTT) using low-cost microcomputer technology. Because the software runs on a standard microcomputer readily available throughout the Air Force, training in many of the basic aspects of electronic combat will soon be available at the squadron level and provide virtually unlimited practice opportunities to aircrew members. Laboratory R&D on part-task training shows the potential of large-scale training benefits versus training dollars invested by applying microcomputer-based training devices as part-task trainers. Research surveys indicated: (a) a need for in-depth R&D on

part-task methodologies for specific types of training tasks (particularly decision aspects); (b) a broad-impact opportunity for application of advanced, low-cost-technology part-task trainers; and (c) the need for demonstrations in real-world training environments. R&D issues include identification of specific methods to optimize part-task training for a variety of requirements.

Research and development in this area is conducted as a close dialog between the user and the Laboratory. Currently the Division sponsors a "lab-in-the-field" concept development program with each of three users: Tactical Air Command (TAC), Strategic Air Command (SAC), and Military Airlift Command (MAC). Trainer design employs Instructional Systems Development principles including task analysis, specification of observable training objectives, development of performance criteria and measures, simulation of task environments to support on-task practice, and automated guidance and feedback systems to support "stand-alone" training. The lab-in-the-field concept begins at the time the trainer is delivered to the user as an experimental device.

With student and instructor pilot populations participating as experimental subjects, each trainer undergoes extensive testing and modification to mature and validate the concept. During this process, researchers manipulate instructional methods such as task partitioning, sequence of instruction, and feedback. Media variables associated with hardware and software characteristics also are evaluated to optimize training effectiveness. The essential thrust of this process is to identify critical determinants of skill development for selected types of aircrew training. These findings will be used to define training procedures and methods, and to identify the requirements of task fidelity and instructional features and other design requirements for operational part-task trainers.

The most recent experimental trainer is the Air Intercept Trainer (AIT), under development for the Air National Guard and the Tactical Air Command. The AIT is capable of training basic radar system operations and beyond visual range aspects of air-to-air intercepts. The trainer simulates the relevant instrumentation, controls, and flight dynamics of the F-16. Initial experimentation on training effectiveness shows that the AIT is an effective substitute for the F-16 flight simulator for many aspects of intercept training. Acceptance by users has been enthusiastic and the operational reliability of the device thus far is extremely high. The AIT will continue in the experimental mode for the next year as enhancements are added and evaluated, and additional experimentation proceeds. Enhancements include a refined intercept scoring algorithm, basic skills pretest module (symbology interpretation and switchology proficiency), automated guidance and feedback, and experimental data collection systems. Experimental training devices similar in concept to the AIT are in design phases for SAC and MAC.

The aggregate knowledge of methods and technology accruing from the development of experimental prototypes will be used to develop a data base on part-task training methodology. The Division is

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Cockpit inside dome simulator visual system and helmet with tracker
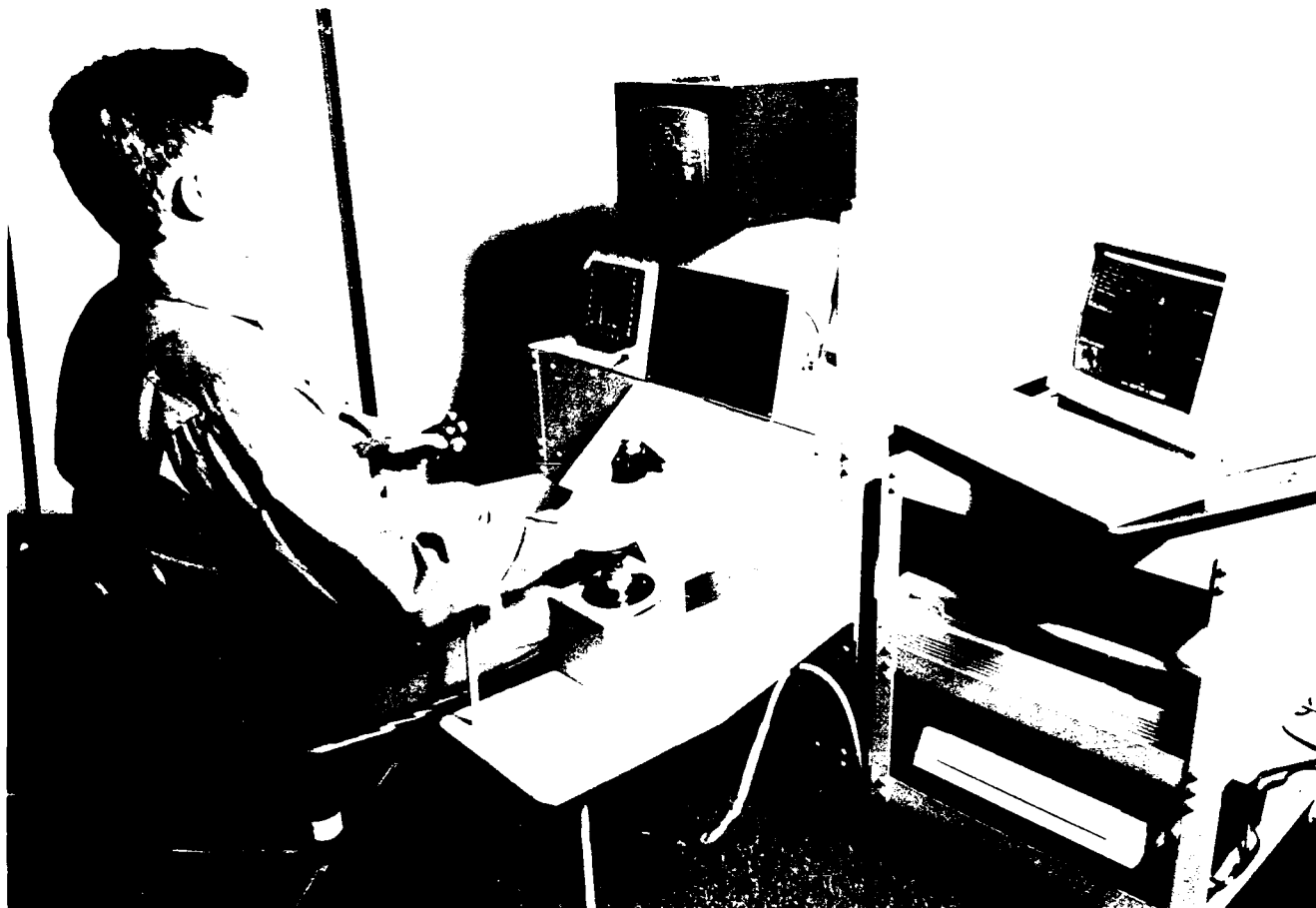
Part-task training can increase skill acquisition while reducing training costs.

sponsoring a separate, related R&D endeavor to develop a comprehensive training methodology model for part-task training which, when complete, will be available to Air Force training designers and managers in a Decision Support System (DSS). The DSS will provide convenient access to the full body of training knowledge relevant to methods selection for a useful range of training requirements within the target training community.

Based upon the success of experimental trainers such as the ECPTT and the AIT, AFHRL/OT's expanded R&D program on methods and technology solutions for part-task training will eventually lead to intelligent, automated devices which can reduce training costs while increasing the proficiency and readiness of operational aircrews.

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Total Training System Design

There is a growing recognition in the Air Force for the need to design and implement aircrew training programs as total integrated systems rather than as disjointed sets of components and phases of training. Many traditional programs are comprised of phases and blocks of instruction that have been independently developed in relative isolation from the "system" as a whole, resulting in frequent gaps in some areas and unnecessary redundancies in others. Resulting programs are inefficient and the aircraft,

To be cost effective, a training program must consider
the total integrated training system.

which is usually the most costly resource in the program, often is used to compensate for instructional deficiencies that should have been corrected in much less expensive ways. This lack of integration into a unified system also leads to programs that are relatively inflexible in adapting to change. For example, when new training technologies are introduced that should improve the overall cost effectiveness of the program, frequently nothing else in the program is changed; thus, the major impact is an overall increase in O&M costs.

The Division has a total training system design R&D program directed toward providing guidelines for the Air Force. The Model Aircrew Training System (MATS) produced a design specification for a new C-130 aircrew training system that took full advantage of recent advances in cognitive psychology and training technology to optimize training effectiveness and efficiency. The resulting specification formed the foundation for the C-130 Aircrew Training System (C-130 ATS). The C-130 ATS is an integrated training system that includes all phases of training. Training is proficiency-based such that student progression is dependent upon meeting predefined performance standards rather than simply completing a fixed number of training events or sessions. Training is individualized to the maximum extent possible so that both the rate and content of training are tailored to the needs and capabilities of each individual rather than to the class as a whole. There is a conscious attempt to increase the overall cost effectiveness of the system and its ability to adapt to change through the rational application of advanced concepts in training design, development, delivery, and management.

There is an increasing need for objective air combat performance
data for both the simulated and real-world environments.

The C-130 ATS also has an aggressive evaluation component to provide information about the effectiveness and efficiency of the ATS and its components to support management decisions and to document lessons learned for future training system applications.

Programs will provide guidelines for designing courseware that fully uses the capabilities of a given training device, for integrating differing media into courses, and for designing total training systems to coordinate all phases of training. Separate instructional strategy efforts will be conducted during the period FY88 to FY92 to develop: (a) guidelines for optimizing feedback during electronic combat training, in which the real-time feedback requirements for implementation on operational ranges and the optimal format and content of post-mission debriefings will be determined (FY88); and (b) guidelines for the con-

struction of combat training syllabi, in which the optimal training scenario content will be defined for close air support (A-10), daytime deep strike (F-16), and night attack interdiction (LANTIRN F-16) (FY89). A manual for total training systems design will be completed in FY92. A training R&D laboratory (TRL) has been established on-site at Little Rock AFB, AK to address training system design issues in the context of the C-130 ATS. Initial tasks for the TRL are: develop improved proficiency metrics both to evaluate the C-130 ATS and to manage proficiency-based training; baseline the effectiveness and efficiency of the current training programs to establish costs and benefits of the ATS and its major components relative to the existing training programs; and generate and evaluate new training strategies based in part on insights gained from a better map of skill acquisition and skill retention that should result from the use

of improved performance metrics. MATS concepts are also currently being applied to the modernization of B-52 and KC-135 aircrew training. In addition to supplying training system design concepts, OT is also working with the Strategic Air Command (SAC) to identify important training system evaluation concepts, practices, and procedures to include in the specification of the new SAC training systems. One major product of this effort will be the formulation of a test and evaluation plan for the B-52 and KC-135 training modernization program. The test plan will be responsive to the information requirements of all levels of management, and it will enable a comprehensive assessment of the effectiveness and efficiency of the new training system and its components.
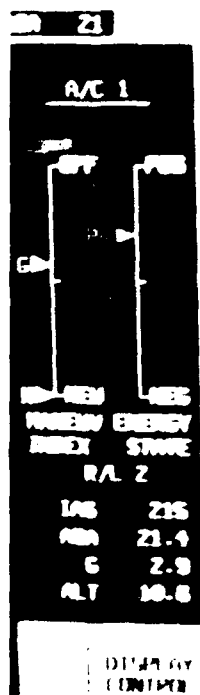
The Air Combat Performance Measurement System
provides for post-mission graphic replay for debriefing.

Finally, to facilitate transfer of lessons learned to other training systems, OT is developing an empirical data base to capture the results of field R&D and results of evaluations of emerging training systems. Based on this data base, guidelines and model specifications will be developed addressing the design, acquisition, and operation of total a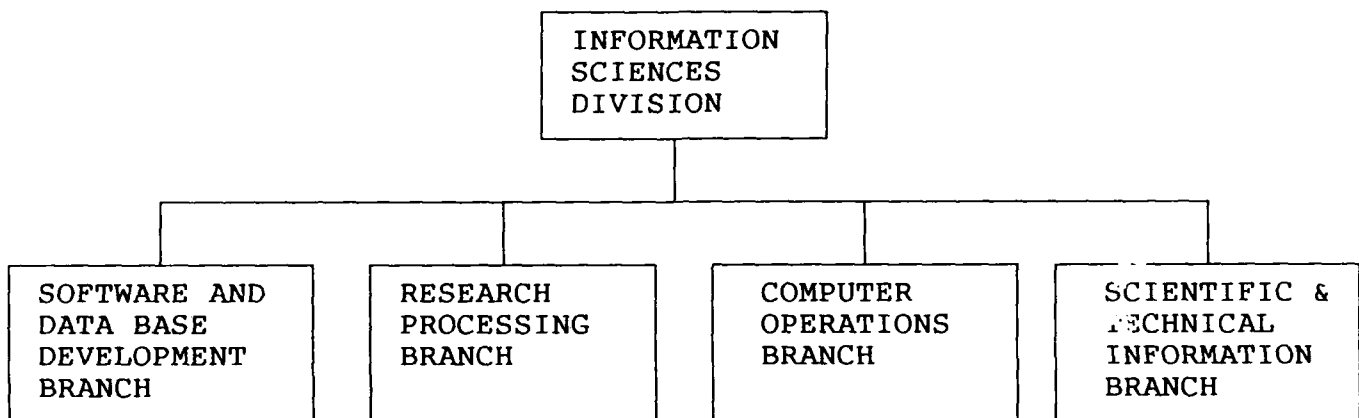ircrew training systems for use by systems acquisition offices and Air Force training organizations to enhance the cost effectiveness of training.

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The Information Sciences Division, located at Brooks AFB, Texas, provides support to the AFHRL headquarters and the four R&D divisions. This support includes management and operation of the scientific data-processing center of AFHRL. Office automation services are also provided by the Division. Management information is maintained on a VAX computer system. The Division develops, maintains, and updates automated personnel and training R&D data bases. The Division also provides consultative and programming support in the formulation of R&D efforts and the application of statistical techniques in support of other Laboratory divisions and Air Force offices. The Division manages the scientific and technical information program. The Division is organized into four branches as shown below.

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                    │ INFORMATION │
                    │ SCIENCES    │
                    │ DIVISION    │
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│ SOFTWARE AND │ │ RESEARCH  │ │ COMPUTER   │ │ SCIENTIFIC & │
│ DATA BASE    │ │ PROCESSING│ │ OPERATIONS │ │ TECHNICAL    │
│ DEVELOPMENT  │ │ BRANCH    │ │ BRANCH     │ │ INFORMATION  │
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## SOFTWARE & DATA BASE DEVELOPMENT BRANCH

The Branch provides three services:

1. Software Development.
2. Research Data Base Management.
3. Management Information.

Software Development. The Branch develops, maintains, documents, and provides training in the use of general-purpose computer software. This software includes the broad categories of (a) language translators, such as precompilers and interpreters; (b) utility programs, such as sort/merge and report writers; (c) applications programs, such as correlation-regression analysis and multidimensional frequency distributions; and (d) subroutine libraries containing common computing algorithms. The Branch is responsible for more than 460 general-purpose and statistical analysis programs and 4,000 pages of user guides to those programs. The majority of this software is installed on the UNISYS 1100, and a rapidly growing microcomputer library is being developed.

Research Data Base Management. The analysis of relationships between personal characteristics and performance during an Air Force career requires the extensive use of data. Experimental tests and performance measurement devices are administered in a research setting, and these results are ordinarily correlated with information about experimental cases using other information developed on the
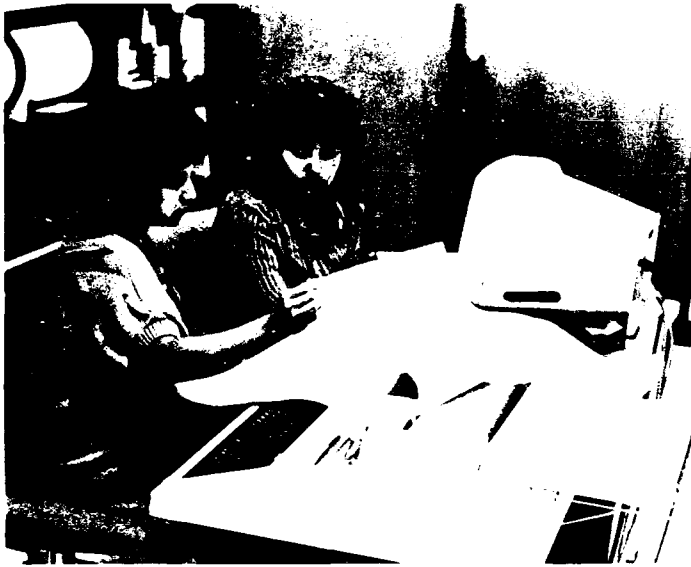
same cases at a different point in time, either earlier or later than the experimental data. Similarly, studies of career progression and factors related to successful completion of an enlistment, or attrition, require the analyst to correlate information on the same individuals across a time span of several years. The major operational commands, whe e background and performance data on military personnel are initially acquired, retain these data for only a limited period--ordinarily less than 1 year. In order to facilitate R&D on the Air Force personnel and training systems by AFHRL researchers, automated data are obtained from the major operating commands on a recurring basis. These data are then converted for use in the AFHRL Computer Center. Based on experience with specific analyses and studies by AFHRL researchers over a period of years, data in these master files are then reorganized in a manner calculated to eliminate as much of the overhead as possible in the context of specific studies. Experience has also indicated the desirability of combining information from two or more master file sources to establish ready-to-use master files with a common set of data for each case in the file. The availability ot the R&D master files makes it possible for researchers to effectively carry out comprehensive R&D efforts related to the personnel and training systems without having to initiate arrangements for data collection on a case-by-case and study-by-study basis with field locations in major operating commands. The AFHRL R&D master files contain data that reflect the personal characteristics of officers and enlisted personnel at time of entry to active duty, performance outcomes during flying or technical training, career status at periodic intervals, and information related to reenlistment or separation. Special files are created to meet long-term study requirements, and longitudinal files have been constructed to facilitate studies in career development. Work is underway to build dynamic officer nd enlisted data base systems capable of providing responses to operational and research investigators. These data base systems will eliminate the requirement for many small, fragmented data bases and further reduce the startup time and cost of many personnel R&D efforts.

Major master personnel files are maintained historically on Air Force enlisted and officer personnel and include enlisted strength files from 1964, officer strength files from 1960, officer effectiveness report files from 1956, flying training files from 1964, Air National Guard and Air Force Reserve files from 1970, separated officer files from 1963,

enlisted separation files from 1956, Basic Military Training files from 1956, Officer Training School files from 1973, and Reserve Officer Training School (ROTC) participant files from 1970. These files are received from various Air Force agencies, such as the Air Force Military Personnel Center, Air Training Command, Air University, and Air Force Reserve Personnel Center. Special longitudinal files, such as the Airman Gain/Loss and Officer Gain/Loss, are developed in-house from these data bases and significantly reduce data processing requirements in many personnel and training R&D efforts.

In order to understand the code structures used in the development of the personnel files, an additional data base was developed and is maintained by AFHRL. This data base is the File Item Data Organizer (FIDO). It consists of selected data elements and code definitions from Air Force Regulation 700-20, Air Force Data Dictionary, and earlier code systems. It has on-line retrieval capability for current and historical code values, with definitions for each data element that appears in a data file. The data base currently contains over 1,100 Air Force and DOD-defined data elements, enabling a researcher to obtain English-language meanings for each code value in effect for any particular historical file. FIDO has proven to be a valuable tool for improving data base accuracy, both at AFHRL and other agencies.

Management Information. This Branch is also the focal point for collecting and displaying data used in the management of the AFHRL technical program. All Laboratory divisions and staff offices have on-line access to the Human Resources Management Information System (HRMIS) to enter and retrieve data. HRMIS is a dynamic data base which currently contains information for work unit management, funding action, R&D contracts, purchase requests, TDY management, Computer System Requirements Documents (CSRD) tracking, facilities management, R&D requirements, interagency agreements, and Laboratory personnel management. Automated data transfer is being done to support Defense Technical Information Center (DTIC), Human Systems Division (HSD), and accounting and finance data bases. Personnel throughout AFHRL retrieve data and produce reports using the AFHRL data base and the Oracle data base management system.

RESEARCH PROCESSING BRANCH

The complexity of comprehensive R&D efforts performed by AFHRL researchers frequently leads to an extensive series of data-processing steps and use of AFHRL computer resources. The design and conduct of these data-processing steps in many cases require the use of technical experts, who select and assemble utility, general-purpose, and statistical programs. Some efforts also require the development of unique software. In many cases, the use of one or more technical experts who have a working knowledge of the R&D master files is critical. The Branch maintains a staff of programmer

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and data base experts who support the analysis requirements of researchers. These services are performed in response to approved work requests initiated by all AFHRL divisions. These same services are available to approved agencies outside AFHRL. Work requests are initiated on behalf of the outside customers and then processed in the same manner as those for the AFHRL divisions. In addition to processing these work requests, the Branch performs a quality review of all work performed, to ensure complete and accurate results. Annually, the Branch services over 200 R&D-data processing requests.

COMPUTER OPERATIONS BRANCH

The Computer Operations Branch manages and operates a computer center which includes a large-scale, general-purpose UNISYS 1100 computer system to support R&D programs of AFHRL and the Human Systems Division (HSD) at Brooks AFB, and the Occupational Measurement Center (OMC) and the Air Force Military Personnel Center (AFMPC) at Randolph AFB. A Digital Equipment Corporation VAX 8600 is operated by the Branch to provide specialized support to the Training Systems Division for the Instructional Support System (ISS) and the Advanced On-the-job Training System (AOTS) applications. A Digital Equipment Corporation VAX 11/780 computer system provides automated management information systems in support of R&D projects within AFHRL and also provides an interface with the Defense Data Network (DDN). A Wang Laboratories VS-100 computer system provides office automation support within AFHRL.

The Computer Center includes a magnetic tape library, which houses 20,000 active tape reels. These tapes contain historical data from Air Force personnel files, which include master files, working files created from data-processing work requests, and system and application software.

Over 300 authorized users access the UNISYS 1100 system via dial-up telephone lines, dedicated telephone lines (servicing Randolph AFB), and direct connected terminals at AFHRL, Brooks. UNISYS 1100 users include AFHRL and HSD scientists and contractors, as well as survey analysts from OMC and AFMPC.

The Wang VS-100 computer system provides office automation support within AFHRL. This system provides local automated word processing capability and electronic mail service to the remote AFHRL divisions and HQ AFSC. The Wang terminals and printers located throughout AFHRL allow users to create, edit, reuse, and print research reports, correspondence, etc., and to store documents on magnetic disks for later retrieval as needed. The electronic mail function allows transmission of correspondence, research reports, etc. to all AFHRL divisions and HQ AFSC.

The Branch operates a high-speed Westinghouse Learning Corporation Scanner which supports the rapid automation of a large quantity of survey and research data collected by Laboratory scientists and OMC occupational analysts. The remote divisions of AFHRL and the headquarters are equipped with a visual/graphics teleconferencing system. This system simultane-

SCIENTIFIC AND TECHNICAL INFORMATION BRANCH

The Scientific and Technical Information (STINFO) Branch plans and directs the STINFO program, including the technical library, to meet the information needs of Laboratory scientists and technicians in managing, monitoring, and conducting R&D. The Branch's technical editing function reviews, processes, and publishes results of R&D projects in the form of technical reports, technical papers, journal articles, special reports, professional papers, and other documents. Technical editing personnel provide guidance to authors and contract monitors to ensure that publications comply with Government regulations and professional standards. They also monitor distribution of AFHRL publications and maintain records for responding to informational requests from the user and scientific communities. STINFO personnel identify the information and publicity needs of the Laboratory and develop news

ously links all the AFHRL sites. Such a linkage makes it possible to conduct a presentation at any of the AFHRL sites, with participation at each of the other sites. The Advanced Teleconferencing Multi-media Communication (ATMC) equipment is the heart of the visual conferencing capability. One ATMC is located at each of the remote sites, and one system, together with a backup, is located at AFHRL headquarters. Each ATMC is capable of creating, storing, and retrieving digital color imagery consisting of text, graphics, and/or photographs and subsequently displaying these images locally on large-screen display systems or on color monitors. Using this system, full-scale visual and color video conferences can be conducted, augmented by voice communication channels through a specially designed bridge located at AFHRL headquarters. The function of the bridge is to balance voice signals, making it possible for the audio conferencing operator to monitor the conference passively. The Branch can provide various types of color output, such as textual slides, pie charts, bargraphs, and line graphs, suitable for viewgraph and 35mm projection.

articles, newsletters, reports, brochures, and displays to meet those needs. The Branch provides liaison services between the HSD Public Affairs Office and the Laboratory. The Branch obtains clearance of information for public release; arranges for visits and services

of reporters, photographers, and audio-visual specialists; and performs special public relations and information assignments as required. Finally, the Branch maintains the AFHRL historical archives, answers historical inquiries, and provides information for the HSD History.
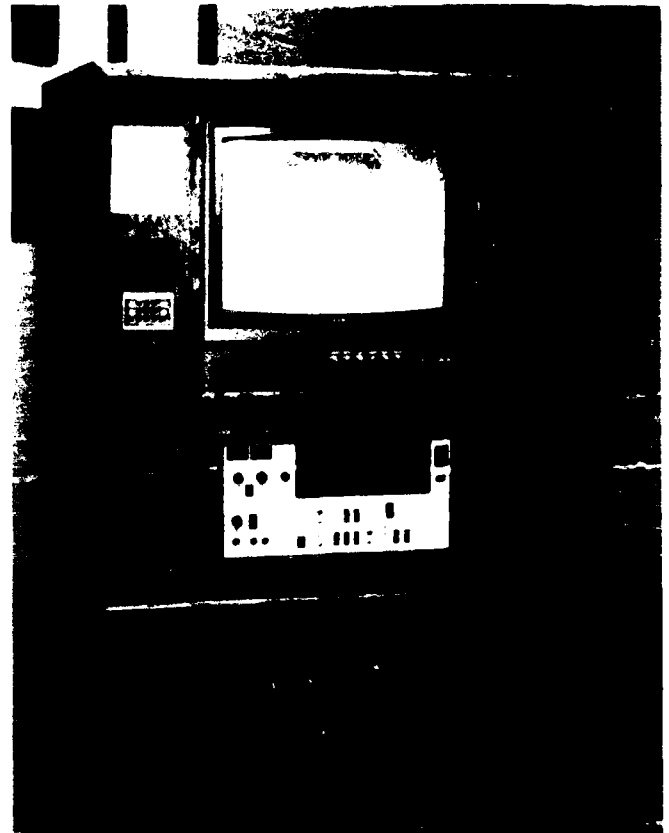

Technical Library

The services provided by the AFHRL library include the acquisition of books, journals, and other library materials.

Services are provided for the command staff offices and the divisions on Brooks AFB, as well as for divisions and offices located in other geographical areas. The library has on-line access to the Dialog Information Services, Inc., at Palo Alto, California; the Defense Technical Information Center's Defense RDT&E On-Line System, at Alexandria, Virginia; and the OCLC, a national library network, through the AMIGOS Bibliographic Council, Inc., Dallas, Texas.

PLANNING FOR THE FUTURE

New procedures and equipment can enhance the support of the Division to the Laboratory R&D program and the Laboratory headquarters. Active studies are underway to identify the requirements for optical disk, to augment the mass storage system on the UNISYS computer. Major sections of the research data base have been identified as candidates for conversion to optical disks. Use of optical disk will significantly reduce the turnaround time associated with the processing of studies which use the research data bases and decrease the requirements for periodically refreshing the large volume of magnetic tape. A study is underway to evaluate low-cost equipment as a possible replacement for the ATMC. Replacement equipment with user-friendly software will enable relatively unskilled clerical and scientific personnel to develop graphics materials as needed.

The Technical Library will install abstracts from technical journals on CD ROM, facilitating literature searches by researchers and scientists. A new level of software is being installed which will significantly speed up the computation of management reports. Major revisions and expansions of existing management information system data bases are being

actively considered to better address the needs of the Laboratory headquarters and staff, as well as the research divisions. The VAX 8600 is being upgraded to a VAX 8650 in order to assure sufficient computational support for the IOT&E of the Advanced On-the-job Training System at Bergstrom AFB scheduled for 1988. Significant progress has been made in streamlining the processing of technical reports and papers, and reducing the number of delinquent reports. New procedures are being implemented to automate tracking of the status of reports in progress and the documentation required for effective work unit management. STINFO focal points at the divisions will be trained by the Laboratory STINFO program manager. Thus, the focal points will be the key to further improvements in the management of the Laboratory STINFO program. While these represent some examples of both processes and equipment which will allow the Division to maintain its level of support to other elements of the Laboratory, Division personnel and managers will remain constantly alert and take aggressive action to improve both the quality and quantity of services provided by the Division.

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